Title: A Heuristic Approach for Profit Optimization in Shared Tenant Services (STS)

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Abstract: The purpose of this project is to maximize profit for a telecommunications system in Shared Tenant Services (STS) for a small office building. The office building is divided into four sections, called bays. Each bay is equipped with the following services: voice communication, data communication, voice message, and facility monitoring. A linear program was formulated with an objective function to maximize the profit for the entire system (building). The decision variables to be solved were the number of extension lines of each service used for each bay. The objective function coefficients were profits corresponding to the decision variables. The criteria were set from the results of a preliminary sample market survey from the tenants of that office building. This prototype linear program has 16 decision variables and 39 constraints, and LINDO was used to solve the linear program.

HEURISTIC APPROACH FOR PROFIT OPTIMIZATION IN SHARED TENANT SERVICES (STS)

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Heuristic Approach for Profit Optimization In Shared Tenant Services (STS)

Project Work

Submitted to Dr.Deckro

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EXECUTIVE SUMMARY

The purpose of this project is to maximize profit for telecommunication system in Shared Tenant Services (STS) for a small office building.

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* We thank Ms.Sue Gains, Telecommunication Manager for Harbor Bay Telecommunications, Alemeda, California for the useful insight during the model development process.

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Table of Contents

	Page number
1) Introduction	4
2) Concept and Technology	5
3) Model development	12
4) Constraint sets	21
5) LINDO Model	24
6) Sensitivity Analysis	33
7) Conclusion	37
8) Appendix	38
9) References	39

Multi-Tenant/Shared Tenant Services

Introduction:

The divestiture of Telecommunication in early 80's has led to rapid pace of technological change in communication and office automation technologies. As a result, an extensive array of integral voice and data communication systems are being offered. Also, the intensified competition present many opportunities for small telephone companies and entrepreneurs in the area of Multi-tenant/Shared Tenant Services (STS).

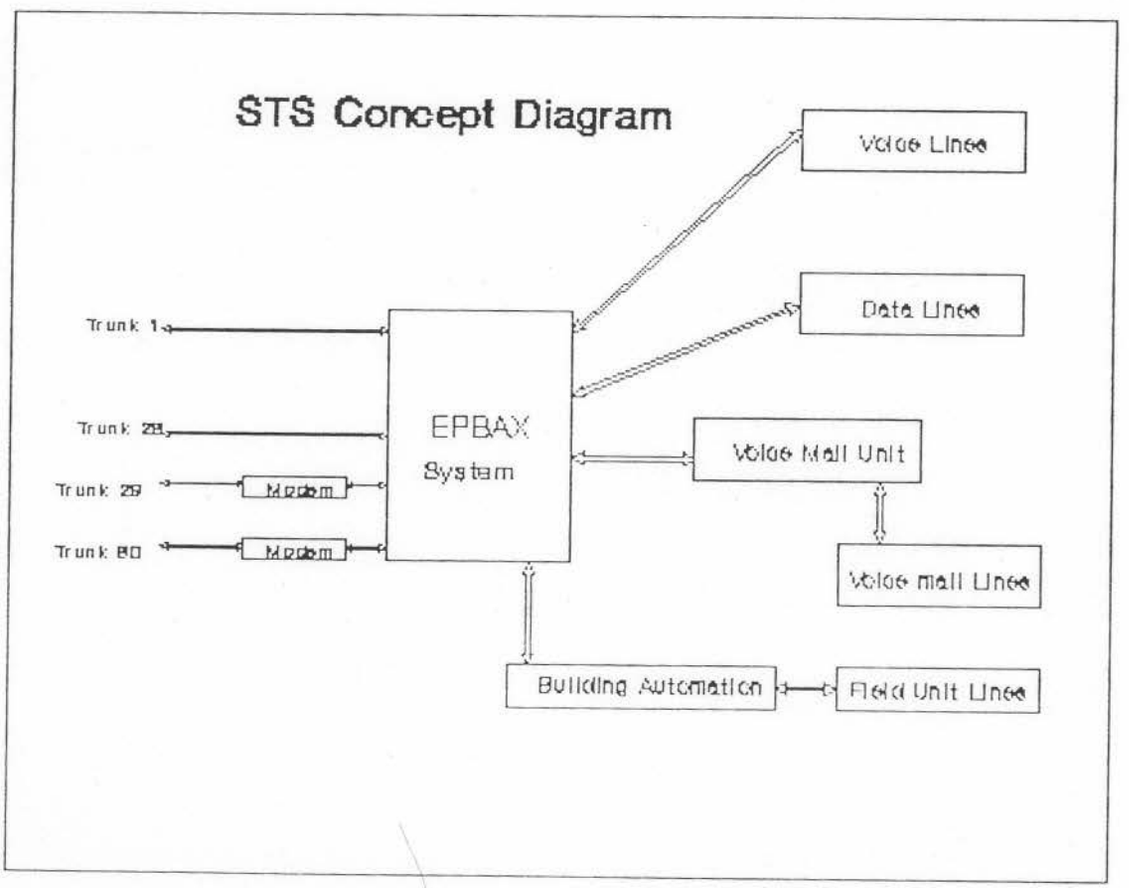
STS involves a service provider, often the owner or the developer of the property, offering tenants communication equipment and services they can use on a shared basis. Service are customized and can range from providing simple telephone, access to PC's, electronic mail to tele or video conference. In generalized perspective, the provider of STS as to match closely the real needs and concerns of tenants with respect to information and communication. In the last several years, there has been a quit restructuring of STS industry. The market as regrouped and begin making progress in certain areas. STS has not made an big impact as many market research firm predicted. However, STS has left its mark on real estate owners as not an revenue source but as a basic amenity of the building.

Lastly, considerable amount of interest and research is being reported in Europe and Japan. STS as broaden its focus on open network architecture STS and would lead into Building Automation Systems (BAS).

Concept and Technology:

STS is essentially an inhouse telephone company (a service company) for office buildings, industrial complexes and shopping malls with compete range of telecom services to offer including data network capability.

The STS facility consists of a PBX switching system operating as a miniature telephone company. On one side of the switch are trunks (Central office lines) that carry traffic to and from the building. On the other side of the switch, lines lead to the telephone or Data extensions of individual tenants.



Central Role of the Private Branch Exchange (PBX)

In the early stages of business telecommunications, each telephone was unique, and had a separate number. In other words, if a business wanted to use several telephones, it would make arrangements to get several telephones from the telephone company. As the number of telephones being used by business increased rapidly, the strain on the central switches connecting these telephones together also increased. If a company had several telephones, and if employees from within the company wished to speak with each other, then their calls were channeled through the telephone company's switch.

In order to cut down costs, the private switchboard was created and each company with a great number of telephones was able to have an operator who would answer the telephone and direct the call. These switchboards were the forerunners of today's Private Branch Exchange (PBX).

The switchboard solution made it possible for the company to purchase only a few lines between itself and the telephone company's switch, thus reducing costs. Each telephone no longer had to be connected to a separate telephone line. In addition, when one person within the company was calling another person within the company, the call could be routed through the switchboard without leaving the company to transit through the telephone company's switch. Naturally, this saved a great deal of

money and was a generally effective solution.

As the microelectronics revolution swept through the world of telephone, the PBX became digital. To the user, a Digital Electronic Private Automatic Branch Exchange (EPABX) does not appear to be any different from an older analogue PBX, except that it offers more features. With EPABX, the switching of telephone circuits takes place though microelectronics, usually through tone dialing instead of pulse dialing. Since EPABX is based on microprocessors, it has many features:

* Programmability of Numbers for Moves

Changing telephone numbers is done through software programming rather than by actually disconnecting and reconnecting telephone wires. This makes it possible for people to "take their telephone numbers with them" as they move from one department to another within an organization.

* Call Detail Reporting and Private Accounting

PBX can provide a complete listing of each call made by each individual telephone, including the charges associated with those calls. In this way, it is possible to isolate the calling patterns of each individual in order to enforce expenditure patterns for long distance calling. Call detail reporting is an important feature for establishing the true source of costs, and it helps a great deal in the management of calling pattern.

* Number Access Control

Another useful feature of the PBX is its ability to discriminate between different telephones. Some telephones can be given complete dialing access to the outside, whereas other telephones may be restricted only to calls within the PBX system or within the organization. Another variation might be allowing local calls within the city, but restricting long distance calls. This feature is very useful for providing universal telephone service within an organization without the risk of uncontrolled login distance telephone bills from persons who should not be calling login distance.

* Speed Dialing

PBX allow the caller to program frequently called numbers so that they can be "speed dialed" using only one or two numbers.

* Automatic Callback and Camp-on

In order to save time spent repeatedly calling a busy extension, the automatic call back option allows the user to place a call automatically when the desired extension become free. It is necessary to dial the busy extension only one, and the PBX will automatically call back the caller when the number that was formerly busy becomes available. The PBX therefore allows the caller to "camp-on" to the busy extension until it becomes available.

* Call Forwarding

Most PBX systems provide an ability to have incoming calls forwarded to another extension on the same PBX within the

organization. The user programs the PBX to turn on call forwarding and keys in the number to which the call should be forwarded. This useful feature helps persons without secretaries to avoid missing important incoming calls because they are temporarily at a different location.

* Call Pickup

Call pickup allows a person to pick up an incoming call which is going to another person's phone. This is useful when the second person is away from his or her desk or out of the office. The software features of the PBX allow pickup groups to be programmed into the system. Person who are in the same pickup group can intercept incoming calls to other persons in their group.

* Conference Calling or Party Calls

This feature allows more than two persons to speak together through the telephone. Usually one person calls a second person, places that person on hold, then calls a third person, and reconnects the second person. At that point, all three persons can speak with one another. Depending on the capabilities of the PBX, it is possible to add more than three persons to a conference call.

* Hold

The hold feature on the PBX allows the user to temporarily suspend a call while doing something else. Under these circumstances, the telephone connection is not lost, and it is

possible to reactivate the call with a simple flash hook.

* Call Transfer

The transfer feature of a digital PBX allows the person receiving a call to redirect it to another extension within the organization. In some organizations with several locations, a call may be redirected not only to another party within the same building, but to an entirely different city, many times without the caller realizing that the call is being redirected such great distances.

* Shared Modems and Data Circuits

Many PBXs also provide access to data circuits. Persons wishing to get access to a data circuit might dial a particular extension to be connected to a modem. The advantage of this is that the cost of the modem can be shared between many occasional users. With today technologies, it is possible to have both data and voice information traveling through the same circuits.

As useful as these many features of the PBX are they are well known. A new type of technology that developed quickly in the late 1980s has made great improvements in customer service for many business organizations. These new technologies give callers different types of options: they might make direct inquiries of a computer, or leave messages for pickup when the person being called is away. A firm can achieve these new capabilities for its telecommunications system by adding new types of equipment to the

PBX network.

* Automatic Call Distribution (ACD) Devices

For a business setting up a call center to handle a large number of incoming calls, the ACD is indispensable in routing calls "to the next available agent who will assist you." The ACD makes sure that calls are distributed evenly among the employees answering the telephone.

* Voice Recognition Equipment

The use of voice recognition equipment has been very successful when a business is required to give a high volume of answers to highly similar questions.

* Voice Response Units and Transaction Processing Interfaces

Voice response units take information from a computer and generate a human voice for the caller. When VRUs are connected to a transaction processing interface unit, a linkage directly to a computer system can be established. * Voice Store and Forward System (Voice Mail)

Voice store and forward systems act more or less like a personal answering machine, except that they are centered in the PBX. Messages can be received remotely, the same as with an answering machine, but messages can also be forwarded to other persons; some messages may be sent to several persons at the same time.

Model development:

The process of modeling hinges on the EPBAX system design. In any communication system design the fundamental design depends on the Grade of service level provided and Traffic Intensity (TI) in area of interest. In this case Bay Area.

Grade of service level:

Generally it is accepted in communication practice, one chooses a grade of service that corresponds to the probability of blocking. For example, P .01 service means that the line will indicate busy for 1 out of 100 calls. Standard communication statistics tables are available from the telephone utility company serving the area of interest (Bay Area). This table is called Erlang C formula Chart. Sample Table is enclosed in Appendix.

Communication Traffic Measurement: (Traffic Intensity - TI)

The international unit of communication traffic measurement is **Erlang** (E). It is dimensionless unit

1 E = 1 hour-call / hour / line.

For example person A calling person B over line-1 and talk for 1-hour, the traffic load on line-1 was 1 E.

In North America the unit of measure is 100 Circuit calls per second (CCS).

1 E = 36 CCS.

Parameters needed to determine TI are:

1) Busy Hour Calls Attempt - BHCA - 5 / line.

2) Average Holding Time - AHT - 1.5 minutes / line

Traffic intensity (TI) or load per line in Bay Area is obtained from the utility company servicing that area.

Type of line	BHCA	AHT	E
Trunk or C.O line (T)	12	3.0	0.6
Extension Line (L)	3	1.5	0.1

From the above table the Extension-to-Trunk ratio is 6:1. For our project the office building under consideration is divided into four bays. The number of offices or tenants in each bay is given below.

Bay-1	Bay-2	Bay-3	Bay-4
5	4	5	6

Services offered are:

VC = Voice Communications

DC = Data Communications

VM = Voice Message

FM = Facility Monitoring

Variable definition table:

Services	Bay-1	Bay-2	Bay-3	Bay-4
Voice Communication	X11	X12	X13	X14
Data Communication	X21	X22	X23	X24
Voice Message	X31	X32	X33	X34
Facility Monitoring	X41	X42	X43	X44

Where
X11 - no. of VC lines in Bay - 1
X12 - no. of VC lines in Bay - 2
X13 - no. of VC lines in Bay - 3
X14 - no. of VC lines in Bay - 4
X21 - no. of DC lines in Bay - 1
X22 - no. of DC lines in Bay - 2
X23 - no. of DC lines in Bay - 3
X24 - no. of DC lines in Bay - 4
X31 - no. of VM lines in Bay - 1
X32 - no. of VM lines in Bay - 2
X33 - no. of VM lines in Bay - 3
X34 - no. of VM lines in Bay - 4
X41 - no. of FM lines in Bay - 1
X42 - no. of FM lines in Bay - 2
X43 - no. of FM lines in Bay - 3
X44 - no. of FM lines in Bay - 4

Market survey table:

A prelimary sample market survey indicates the possible demand range, minimum - maximum number of extension lines the tenants of the office building felt needed.

Demand Table:

Services	Bay-1	Bay-2	Bay-3	Bay-4	Range
Voice Communication	8-15	7-10	6-12	6-13	27-50
Data Communication	5-8	6-9	4-6	4-6	19-29
Voice Message	7-14	5-8	4-10	3-9	19-41
Facility Monitoring	5-15	4-12	5-15	6-18	20-60
Range on Bays	25-52	22-39	19-42	19-46	85/180

From the sample survey table the total no of lines required is the total of the maximum range number = 180 extensions

Our objective is to find the optimal solution for maximization of profit by Linear programming model. The solution of the model will give us the optimal allocation of the extension lines to services and Bay wise.

Objective Function:

z = Maximize Profit.

Max z = d1 (X11 + X12 + X13 + X14)

+ d2 (X21 + X22 + X23 + X24)

+ d3 (X31 + X32 + X33 + X34)

+ d4 (X41 + X42 + X43 + X44)

Where, d1 is profit in $ per extension from voice communication

d2 is profit in $ per extension from data communication

d3 is profit in $ per extension from voice message

d4 is profit in $ per extension from facility monitoring.

Economic Analysis on Capital Equipment:

To determine d1 - d4, economic analysis on capital equipment is required and calculations is shown below.

The system requirements are:

Extension to Trunk ratio is 6:1 (Ref page - 11)

Total number of extension is 180

Therefore, the number trunk lines required is 180 / 6 = 30

Types of equipment:

- EPBAX 30 X 180
- Computer Systems (2 Mips)
- Voice mail equipment
- Fax machine / card
- Modem card
- Protocol converter
- Communication software

Please note:

In calculating d4, the cost of extension line provided is only considered. Cost magnetic door access units and central system not included cost analysis. The EPABX is just a switching interface between door access units and the central building monitoring system. It is done so to eliminated confusion and integrate all low voltage wiring in the building.

Life cycle of capital investment = 5 years

Cost of capital (interest) = 10% P.A.

Aggregate cost of 30 X 180 lines EPBAX = $ 16,000

Computer System = $ 8,000

Voice mail equipment = $ 12,000

Modem = $ 3,500

Protocol converter = $ 4,000

Communication software = $ 1,000

Trunk line installation (30L @ $50) = $ 1,500

Wiring cost (200 L @ 20) = $ 4,000

Total cost of equipment = $ 50,000

Capital recovery factor $(A/P)^{10\%\ p.a}_{5\ years}$ = 0.2638.

(from tables made available in any engineering economic book)

Annualized Equipment Cost (AEC) = $ 50,000 * 0.2638 = $ 13,190 P.A.

Operating Expenses:

General Administration ($40 P.A. * 180L)= $ 7,200

Maintenance ($44 P.A. * 180L) = $ 7,920

Utilities ($ 6 P.A. * 180L) = $ 1,080

Local trunk service charge = $ 6,480

($18 * 12 months * 30 Trunks)

Insurance ($ 7 P.A. * 180L) = $ 1,260

Total operating cost P.A. = $ 23,940

Total cost equipment $/P.A	13,190
Total Operating cost $/P.A	23,940
Total cost $/P.A.	37,130
Charge perline per Month*	$17.00

*37130/(180 lines * 12 months) = $ 17/line/month.

Services	Charges in $/line	Cost in $/line	Profit in $/line	Decision Co-efficients
Voice Communication	18.00	17.00	1.00	d1
Data Communication	30.00	17.00	13.00	d2
Voice Message	20.00	17.00	3.00	d3
Facility Monitoring	24.00	17.00	7.00	d4

Constraint sets:

Monthly total charge must be greater than monthly total cost.

i.e,

18 X11 + 18 X12 + 18 X13 + 18 X14 + 30 X21 + 30 X22 + 30 X23 + 30 X24 + 20 X31 + 20 X32 + 20 X33 + 20 X34 + 24 X41 + 24 X42 + 24 X43 + 24 X44 >= 3060

Sample survey indication of Minimum number of lines required.

i.e,

X11 + X12 + X13 + X14 + X21 + X22 + X23 + X24 + X31 + X32 + X33 + X34 + X41 + X42 + X43 + X44 >= 85

Sample survey indication of Maximum number of lines required.

i.e,

X11 + X12 + X13 + X14 + X21 + X22 + X23 + X24 + X31 + X32 + X33 + X34 + X41 + X42 + X43 + X44 <= 180

Bay-1 Minimum capacity constraint.

X11 + X21 + X31 + X41 >= 25

Bay-2 Minimum capacity constraint.

X12 + X22 + X32 + X42 >= 22

Bay-3 Minimum capacity constraint.

X13 + X23 + X33 + X43 >= 19

Bay-4 Minimum capacity constraint.

X14 + X24 + X34 + X44 >= 19

Bay-1 Maximum capacity constraint.

X11 + X21 + X31 + X41 <= 52

Bay-2 Maximum capacity constraint.

X12 + X22 + X32 + X42 <= 39

Bay-3 Maximum capacity constraint.

X13 + X23 + X33 + X43 <= 42

Bay-4 Maximum capacity constraint.

X14 + X24 + X34 + X44 <= 46

Voice Communication Minimum Constraint.

X11 + X12 + X13 + X14 >= 27

Data Communication Minimum Constraint.

X21 + X22 + X23 + X24 >= 19

Voice Message Minimum Constraint.

X31 + X32 + X33 + X34 >= 19

Facility Monitoring Minimum Constraint.

X41 + X42 + X43 + X44 >= 20

Voice Communication Maximum Constraint.

X11 + X12 + X13 + X14 <= 50

Data Communication Maximum Constraint.

X21 + X22 + X23 + X24 <= 29

Voice Message Maximum Constraint.

X31 + X32 + X33 + X34 <= 41

Facility Monitoring Maximum Constraint.

X41 + X42 + X43 + X44 <= 60

Whatever happens atleast tenants will require Voice Communication lines. Minimum Voice communication Constraint.

X11 >= 8

X12 >= 7

X13 >= 6

X14 >= 6

Generally Voice Communication services have are greater then Data Communication and Voice Message services.

X11 - X21 >= 0 for Bay-1

X12 - X22 >= 0 for Bay-2

X13 - X23 >= 0 for Bay-3

X14 - X24 >= 0 for Bay-4

X11 - X31 >= 0 for Bay-1

X12 - X32 >= 0 for Bay-2

X13 - X33 >= 0 for Bay-3

X14 - X34 >= 0 for Bay-4

EPABX lines are used for interface Magnetic door access units to Building Automation System. Atleast one door access is needed for each office unit. Three lines or access units per office unit is the Maximum allowed per office in each bay.

X41 >= 5 X41 <= 15

X42 >= 4 X42 <= 12

X43 >= 5 X43 <= 15

X44 >= 6 X44 <= 18

LINDO Model:

```
MAX Z =  X11 + X12 + X13 + X14 + 13 X21 + 13 X22 + 13 X23 +
      13 X24 + 3 X31 + 3 X32 + 3 X33 + 3 X34 + 7 X41 + 7 X42
     + 7 X43 + 7 X44

SUBJECT TO

    2) 18 X11 + 18 X12 + 18 X13 + 18 X14 + 30 X21 + 30 X22
     + 30 X23 + 30 X24 + 20 X31 + 20 X32 + 20 X33 + 20 X34
     + 24 X41 + 24 X42 + 24 X43 + 24 X44 >=   3060

    3)   X11 + X12 + X13 + X14 + X21 + X22 + X23 + X24 + X31
       + X32 + X33 + X34 + X41 + X42 + X43 + X44 >=   85

    4)  X11 + X12 + X13 + X14 + X21 + X22 + X23 + X24 + X31
      + X32 + X33 + X34 + X41 + X42 + X43 + X44 <=   180

    5)  X11 + X21 + X31 + X41 >=   25

    6)  X12 + X22 + X32 + X42 >=   2

    7)  X13 + X23 + X33 + X43 >=   19

    8)  X14 + X24 + X34 + X44 >=   19

    9)  X11 + X21 + X31 + X41 <=   52

   10)  X12 + X22 + X32 + X42 <=   39

   11)  X13 + X23 + X33 + X43 <=   42

   12)  X14 + X24 + X34 + X44 <=   46

   13)  X11 + X12 + X13 + X14 >=   27

   14)  X21 + X22 + X23 + X24 >=   19

   15)  X31 + X32 + X33 + X34 >=   19

   16)  X41 + X42 + X43 + X44 >=   20

   17)  X11 + X12 + X13 + X14 <=   50
```

```
18)   X21 + X22 + X23 + X24 <=   29
19)   X31 + X32 + X33 + X34 <=   41
20)   X41 + X42 + X43 + X44 <=   60
21)   X11 >=   8
22)   X12 >=   7
23)   X13 >=   6
24)   X14 >=   6
25)   X11 - X21 >=   0
26)   X12 - X22 >=   0
27)   X13 - X23 >=   0
28)   X14 - X24 >=   0
29)   X11 - X31 >=   0
30)   X12 - X32 >=   0
31)   X13 - X33 >=   0
32)   X14 - X34 >=   0
33)   X41 >=   5
34)   X42 >=   4
35)   X43 >=   5
36)   X44 >=   6
37)   X41 <=   15
38)   X42 <=   12
39)   X43 <=   15
40)   X44 <=   18
END
```

LP OPTIMUM FOUND AT STEP 24

OBJECTIVE FUNCTION VALUE

1) 969.00000

VARIABLE	VALUE	REDUCED COST
X11	14.500000	.000000
X12	13.500000	.000000
X13	11.666670	.000000
X14	9.333333	.000000
X21	8.000000	.000000
X22	.000000	.000000
X23	11.666670	.000000
X24	9.333333	.000000
X31	14.500000	.000000
X32	13.500000	.000000
X33	3.666667	.000000
X34	9.333333	.000000
X41	15.000000	.000000
X42	12.000000	.000000
X43	15.000000	.000000
X44	18.000000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	952.000000	.000000
3)	94.000000	.000000
4)	1.000000	.000000
5)	27.000000	.000000
6)	17.000000	.000000
7)	23.000000	.000000
8)	27.000000	.000000
9)	.000000	1.000000
10)	.000000	1.000000
11)	.000000	1.000000
12)	.000000	1.000000
13)	22.000000	.000000
14)	10.000000	.000000
15)	22.000000	.000000
16)	40.000000	.000000
17)	1.000000	.000000
18)	.000000	12.000000
19)	.000000	2.000000
20)	.000000	.000000
21)	6.500000	.000000
22)	6.500000	.000000
23)	5.666667	.000000
24)	3.333333	.000000
25)	6.500000	.000000

26)	13.500000	.000000
27)	.000000	.000000
28)	.000000	.000000
29)	.000000	.000000
30)	.000000	.000000
31)	8.000000	.000000
32)	.000000	.000000
33)	10.000000	.000000
34)	8.000000	.000000
35)	10.000000	.000000
36)	12.000000	.000000
37)	.000000	6.000000
38)	.000000	6.000000
39)	.000000	6.000000
40)	.000000	6.000000

NO. ITERATIONS= 24

RANGES IN WHICH THE BASIS IS UNCHANGED:

	OBJ COEFFICIENT RANGES		
VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X11	1.000000	.000000	.000000
X12	1.000000	.000000	.000000
X13	1.000000	.000000	.000000
X14	1.000000	.000000	3.000000
X21	13.000000	.000000	.000000
X22	13.000000	.000000	INFINITY
X23	13.000000	3.000000	.000000
X24	13.000000	.000000	.000000
X31	3.000000	.000000	.000000
X32	3.000000	12.000000	.000000
X33	3.000000	.000000	1.500000
X34	3.000000	.000000	.000000
X41	7.000000	INFINITY	6.000000
X42	7.000000	INFINITY	6.000000
X43	7.000000	INFINITY	6.000000
X44	7.000000	INFINITY	6.000000

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	3060.000000	952.000000	INFINITY
3	85.000000	94.000000	INFINITY
4	180.000000	INFINITY	1.000000
5	25.000000	27.000000	INFINITY
6	22.000000	17.000000	INFINITY
7	19.000000	23.000000	INFINITY
8	19.000000	27.000000	INFINITY
9	52.000000	1.000000	6.500000
10	39.000000	1.000000	8.000000
11	42.000000	1.000000	6.500000
12	46.000000	1.000000	6.500000
13	27.000000	22.000000	INFINITY
14	19.000000	10.000000	INFINITY
15	19.000000	22.000000	INFINITY
16	20.000000	40.000000	INFINITY
17	50.000000	INFINITY	1.000000
18	29.000000	3.250000	1.000000
19	41.000000	4.000000	1.000000
20	60.000000	INFINITY	.000000
21	8.000000	6.500000	INFINITY
22	7.000000	6.500000	INFINITY

23	6.000000	5.666667	INFINITY
24	6.000000	3.333333	INFINITY
25	.000000	6.500000	INFINITY
26	.000000	13.500000	INFINITY
27	.000000	6.500000	11.000000
28	.000000	6.500000	9.999999
29	.000000	8.000000	5.500000
30	.000000	8.000000	5.500000
31	.000000	8.000000	INFINITY
32	.000000	8.000000	5.500000
33	5.000000	10.000000	INFINITY
34	4.000000	8.000000	INFINITY
35	5.000000	10.000000	INFINITY
36	6.000000	12.000000	INFINITY
37	15.000000	.000000	1.000000
38	12.000000	.000000	1.000000
39	15.000000	.000000	1.000000
40	18.000000	.000000	1.000000

SOLUTIONS (from LINDO Printout)

The objective function value is 969.00. This means that the total monthly profit for the entire STS system is $969.00. The number of extension lines for each service for each bay resulted from the LP are listed below:

	Bay 1	Bay 2	Bay 3	Bay 4
Voice Communication	15	14	12	9
Data Communication	8	0	12	9
Voice Message	15	14	4	9
Facility Monitoring	15	12	15	18

The reduced costs for all decision variables are zero. The reduced cost is defined as the amount by which profit will decrease if the nonbasic variable is increased by 1 (while all other nonbasic variables remain equal to zero). In this case, since all reduced costs are zero, then there were no nonbasic variables.

SENSITIVITY ANALYSIS (Refer to LINDO Printout)

Objective Function Coefficient Ranges

If the objective function coefficients stay within the following ranges, then the optimal solution remains unchanged.

1.00 < C11 < 1.00

1.00 < C12 < 1.00

1.00 < C13 < 1.00

1.00 < C14 < 1.00

13.00 < C21 < 13.00

-INF < C22 < 13.00

13.00 < C23 < 16.00

13.00 < C24 < 13.00

3.00 < C31 < 3.00

3.00 < C32 < 15.00

1.50 < C33 < 3.00

3.00 < C34 < 3.00

1.00 < C41 < INF

1.00 < C42 < INF

1.00 < C43 < INF

1.00 < C44 < INF

Dual Prices (Shadow Prices)

If there were one more extension line available for each bay 1, 2, 3, and 4, then we would earn an extra $1.00 profit from each of the bays.

If there were one more extension line available for Facility Monitoring for each bay 1, 2, 3, and 4, then we would earn an extra $6.00 profit from each of the bays.

If there were one more extension line available for Data Communication service, we would earn an extra $12.00 profit.

If there were one more extension line available for Voice Message service, then we would earn an extra $2.00 profit.

Slacks and Surpluses

See LINDO printout for the slack or surplus of each constraint. The numbers in the Slack or Surplus column are slacks or surpluses must satisfy the constraints in order for LINDO to solve for the optimal solution of 969.00. If the constraint has <=, then the number is slack. If the constraint has >=, then the number is surplus.

Righthand Side Ranges

If the righthand sides of the constraints stay within the following ranges, then the optimal solution remains unchanged.

-INF < ROW2 < 4012

-INF < ROW3 < 179

179 < ROW4 < INF

-INF < ROW5 < 52

-INF < ROW6 < 39

-INF < ROW7 < 42

-INF < ROW8 < 46

45.5 < ROW9 < 53

31 < ROW10 < 40

35.5 < ROW11 < 43

39.5 < ROW12 < 47

-INF < ROW13 < 49

-INF < ROW14 < 29

-INF < ROW15 < 41

-INF < ROW16 < 60

49 < ROW17 < INF

28 < ROW18 < 25.75

40 < ROW19 < 37

60 < ROW20 < INF

-INF < ROW21 < 14.5

-INF < ROW22 < 13.5

-INF < ROW23 < 11.67

-INF < ROW24 < 9.33

-INF < ROW25 < 6.5

-INF < ROW26 < 13.5

-11 < ROW27 < 6.5

-10 < ROW28 < 6.5

-5.5 < ROW29 < 8

-5.5 < ROW30 < 8

-INF < ROW31 < 8

-5.5 < ROW32 < 8

-INF < ROW33 < 15

-INF < ROW34 < 12

-INF < ROW35 < 15

-INF < ROW36 < 18

14 < ROW37 < 15

11 < ROW38 < 12

14 < ROW39 < 15

17 < ROW40 < 18

CONCLUSION:

Based on our output from LINDO, the maximum profit that we could get for the entire STS system is $969.00. If we could add another extension line we would add a line for data communication since it has the largest shadow price of $12.00, that is an increase of $12.00 in profit.

Since the profit for the entire system is only $969.00 per month, we would not want to invest in this office building under the stated conditions and constraints from the preliminary market survey. Obviously, $969.00 monthly profit does not look attractive.

If we were to invest in this office building, the profit needs to be reasonable. To do this, we need to increase monthly charge for the services or install more lines to the building. If the above options did not work then we can look at the option of lowering the equipment and operating cost, possibly by renting equipment instead of buying, in order to obtain higher profit.

The biggest hang up for this project was to come up with the monthly costs for the services. Even though Harbor Bay Telecommunications provided us with other telecommunication data information, they did not provide the cost data. Cost data in this business is proprietary, therefore, we could not get them from anywhere else either. We gathered information from past knowledge, articals and documents to come up with the costs for the services for this project. Until real cost information can be obtained, the costs used for this project remain as estimates.

Appendix

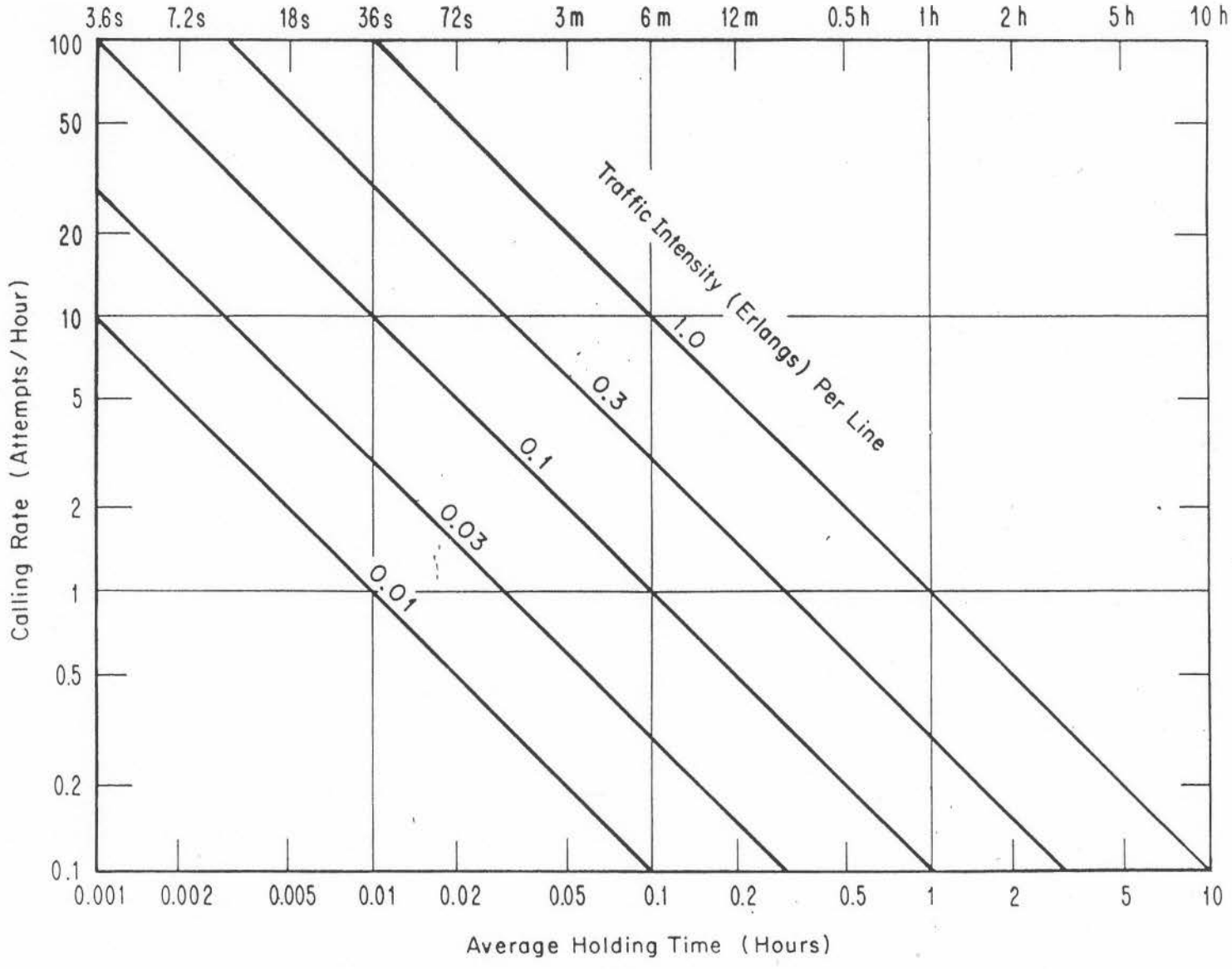


Figure 14. Traffic intensity per line as a function of call rate and holding time.

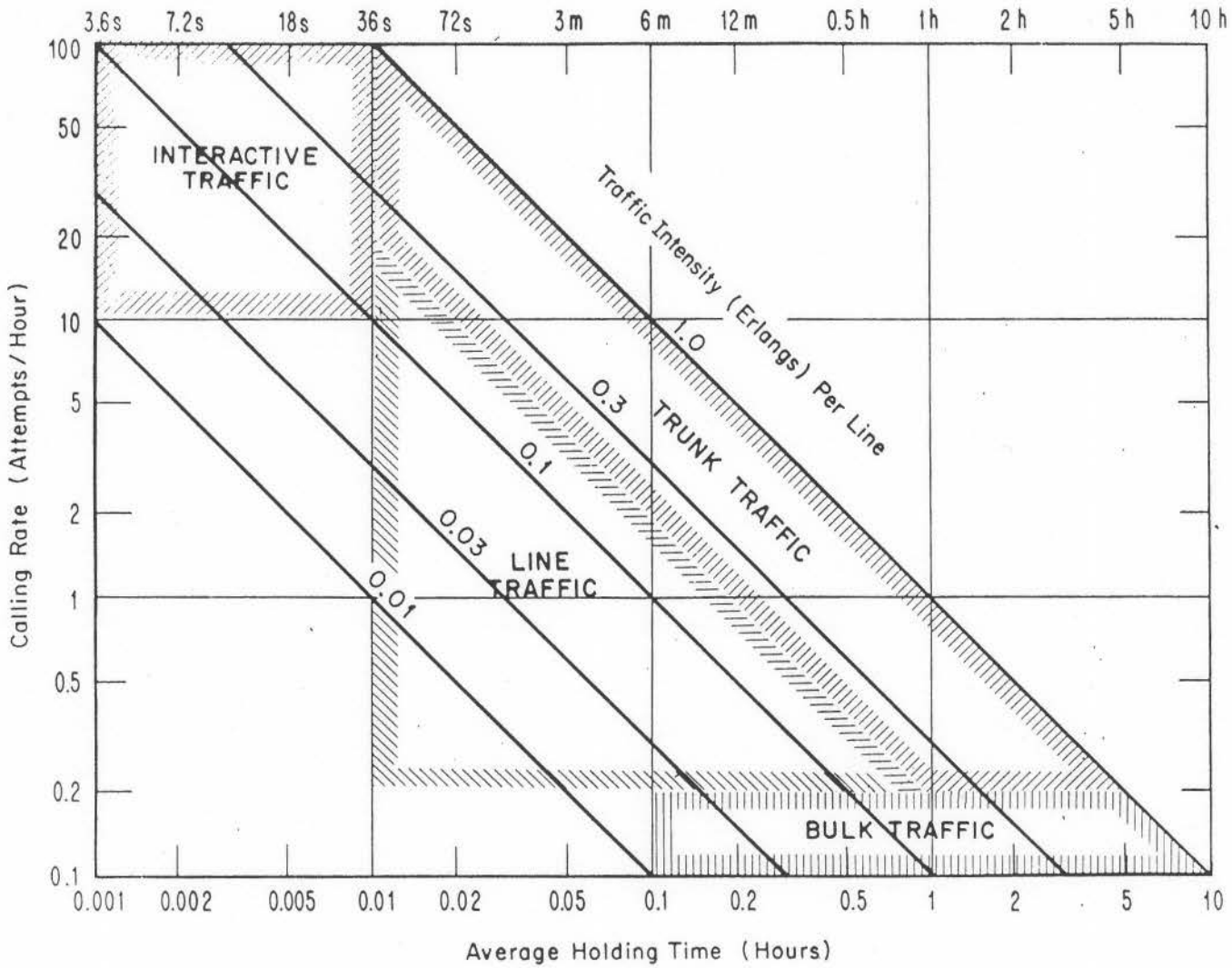


Figure 15. Approximate operating ranges for line and trunk traffic.

Appendix A. Poisson Distribution Tables, 1–100 Lines to P10

Hundred Call Seconds and Percent Use at Various Service Levels for Group Sizes of 1 to 50

The table number indicates the number of calls per 1000 encountering all equipment in the group busy.

Trunks	Table 1		Table 5		Table 10		Table 20		Table 30		Table 40		Table 50		Table 60		Table 70		Table 80		Table 90		Table 100		Trunks
	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	
1	.1	.1	.2	.5	.4	1.0	.7	2.0	1.1	3.1	1.5	4.2	1.9	5.1	2.2	6.2	2.6	7.3	3.0	8.3	3.4	9.4	3.8	10.5	1
2	1.6	2.3	3.7	4.8	5.4	7.5	7.9	10.9	9.7	13.5	11.3	15.7	12.9	17.9	14.2	19.7	15.5	21.7	16.8	23.3	18.0	25.0	19.1	26.7	2
3	6.9	6.4	12.2	11.3	15.7	14.5	20.4	18.9	24.0	22.2	26.9	24.9	29.4	27.2	31.7	29.4	33.9	31.4	35.9	53.3	37.8	35.0	39.6	36.7	3
4	15.4	10.7	24.2	16.8	29.6	20.6	36.7	25.5	41.6	28.9	45.7	31.8	49.1	34.1	52	36.1	55	38.3	58	40.3	60	41.7	63	43.9	4
5	26.6	14.8	38.9	21.6	46.1	25.6	55.8	31.0	61.6	34.2	66.6	37.0	70.9	39.5	75	41.7	78	43.3	81	45.0	85	47.2	88	48.9	5
6	40.0	18.5	55.4	53.7	64.4	29.8	76.0	35.2	82.8	38.3	89.3	41.3	94.1	43.5	99	45.8	103	47.8	107	49.4	110	50.8	113	52.2	6
7	54.7	21.7	73.4	29.1	83.9	33.3	96.8	38.4	105	41.7	112	44.4	118	46.8	123	48.9	128	50.8	132	52.5	136	53.9	140	55.6	7
8	70.9	24.6	92.5	32.1	105	36.5	119	41.3	129	44.8	137	47.6	143	49.7	149	51.7	154	53.6	159	55.2	163	56.7	168	58.3	8
9	88.2	27.2	113	34.9	126	38.9	142	43.8	153	47.2	162	50.0	169	52.2	175	53.9	181	56.8	186	57.5	191	58.9	195	60.3	9
10	107	29.7	134	37.2	149	41.4	166	46.1	178	49.4	188	52.2	195	54.2	202	56.1	208	57.6	214	59.4	219	60.8	224	62.2	10
11	126	31.8	156	39.4	172	43.4	191	48.2	204	51.5	214	54.0	222	56.1	230	58.1	236	59.7	242	61.1	248	62.5	253	63.9	11
12	145	33.6	178	41.2	195	45.1	216	50.0	230	53.3	240	55.6	249	56.9	258	59.7	264	61.1	270	62.5	277	64.2	282	65.3	12
13	166	35.5	201	42.9	220	47.0	241	51.5	256	54.7	267	57.1	277	59.2	286	61.1	292	62.5	299	63.9	306	65.3	311	66.4	13
14	187	37.1	224	44.4	244	48.4	267	53.0	283	56.1	295	58.5	305	60.5	314	62.2	321	63.6	328	65.0	335	66.4	341	67.8	14
15	208	38.5	248	45.9	269	49.8	293	54.3	310	57.4	322	89.6	333	61.7	342	63.3	350	64.7	357	66.1	364	67.6	370	68.6	15
16	231	40.0	273	47.4	294	51.1	320	55.6	337	58.5	350	60.8	362	62.9	371	64.4	379	65.8	387	67.2	394	68.3	401	69.7	16
17	253	41.3	297	48.5	320	52.3	347	56.7	365	59.6	378	61.8	390	63.7	400	65.3	409	66.9	416	68.1	424	69.2	431	70.6	17
18	276	42.6	322	49.7	346	53.4	374	57.7	392	60.5	407	62.8	419	64.7	429	66.1	438	67.6	446	68.9	455	70.3	462	71.4	18
19	299	43.7	347	50.7	373	54.5	401	58.6	420	61.4	436	63.8	448	65.5	458	66.9	468	68.3	476	69.7	485	70.8	492	71.9	19
20	323	44.9	373	51.8	399	55.4	429	59.6	449	62.4	465	64.6	477	66.3	488	67.8	498	69.2	506	70.3	516	71.7	523	72.8	20
21	346	45.8	399	52.8	426	56.4	458	60.6	478	63.2	494	65.3	507	67.1	517	68.3	528	69.7	537	71.1	546	72.2	554	73.3	21
22	370	46.7	424	53.5	453	57.2	486	61.4	507	64.0	523	66.0	536	67.7	547	69.2	558	70.6	567	71.7	577	72.8	585	73.9	22
23	395	47.7	451	54.5	480	58.0	514	62.3	536	64.7	552	66.7	566	68.4	577	69.7	589	71.1	598	72.2	607	73.3	616	74.4	23
24	419	48.5	477	55.2	507	58.7	542	62.8	564	65.3	582	67.4	596	69.0	608	70.3	619	71.7	629	72.8	638	73.9	647	75.0	24
25	444	49.3	504	56.0	535	59.4	571	63.4	593	65.9	611	67.9	626	69.6	638	70.8	650	72.2	660	73.3	669	74.4	678	75.3	25
26	469	50.1	531	56.7	562	60.1	599	64.0	623	66.6	641	68.5	656	70.1	669	71.4	680	72.8	691	73.9	700	74.7	710	75.8	26
27	495	50.9	558	57.4	590	60.7	627	64.5	652	67.1	671	68.9	686	70.6	699	71.9	711	73.1	722	74.2	731	75.3	741	76.1	27
28	520	51.6	585	58.0	618	61.3	656	65.1	682	67.7	701	69.6	717	71.1	730	72.5	742	73.6	753	74.7	763	75.6	773	76.7	28
29	545	52.2	612	58.6	647	62.0	685	65.6	711	68.1	731	70.0	747	71.6	761	72.8	773	74.2	784	75.0	794	76.1	805	77.2	29
30	571	52.9	640	59.3	675	62.5	715	66.2	741	68.6	762	70.6	778	72.0	792	73.3	804	74.4	815	75.6	826	76.4	836	77.5	30
31	597	53.5	667	59.8	703	63.0	744	66.7	771	69.1	792	71.0	809	72.5	823	73.6	835	74.7	846	75.8	858	76.9	868	77.8	31
32	624	54.2	695	60.3	732	63.6	773	67.1	801	69.5	822	71.4	840	72.9	854	74.2	867	75.3	878	76.1	890	77.2	900	78.1	32
33	650	54.7	723	60.8	760	64.0	803	67.6	831	69.9	852	71.7	871	73.3	885	74.4	898	75.6	909	76.4	922	77.5	932	78.3	33
34	676	55.2	751	61.4	789	64.5	872	68.0	861	70.3	883	72.1	902	73.7	917	75.0	930	76.1	941	76.9	954	78.1	964	78.9	34
35	703	55.8	779	61.8	818	64.9	862	68.4	891	70.7	913	72.5	933	74.1	948	75.3	961	76.4	973	77.2	986	78.3	996	79.2	35
36	729	56.3	807	62.3	847	65.4	892	68.8	922	71.1	94[illegible]	72.8	964	74.4	979	75.6	993	76.7	1005	77.5	1018	78.6	1028	79.3	36
37	756	56.8	836	62.8	878	65.8	922	69.2	952	71.5	975	73.2	995	74.7	1011	75.8	1024	76.9	1037	77.8	1050	78.9	1060	79.6	37
38	783	57.3	864	63.2	905	66.2	952	69.6	982	71.8	1006	73.5	1026	75.0	1042	76.1	1056	77.2	1069	78.1	1082	79.2	1092	79.7	38
39	810	57.7	892	63.5	935	66.6	982	69.9	1013	72.1	1037	73.9	1057	75.3	1074	76.5	1087	77.5	1101	78.4	1114	79.4	1125	80.1	39
40	837	58.1	921	64.0	964	66.9	1012	70.3	1043	72.4	1069	74.2	1088	75.6	1105	76.8	1119	77.8	1133	78.7	1146	79.6	1157	80.4	40
41	865	58.6	950	64.4	993	67.3	1042	70.6	1074	72.8	1099	74.4	1120	75.9	1137	76.9	1151	78.1	1165	78.9	1178	79.8	1190	80.6	41
42	892	59.0	979	64.7	1023	67.7	1072	70.9	1104	73.0	1130	74.7	1151	76.1	1168	77.2	1183	78.3	1197	79.2	1210	80.0	1222	80.8	42
43	919	59.4	1008	65.1	1052	68.0	1103	71.3	1135	73.3	1161	75.0	1183	76.4	1200	77.5	1215	78.5	1229	79.4	1243	80.3	1255	81.1	43
44	947	59.8	1036	65.4	1082	68.3	1133	71.5	1166	73.6	1192	75.3	1214	76.6	1232	77.8	1247	78.7	1262	79.7	1275	80.6	1287	81.3	44
45	975	60.2	1066	65.8	1112	68.6	1164	71.8	1197	73.9	1223	75.5	1246	76.9	1263	78.1	1279	78.9	1294	79.9	1308	80.8	1320	81.4	45
46	1003	60.6	1095	66.1	1142	69.0	1194	72.1	1228	74.2	1255	75.8	1277	77.1	1295	78.2	1311	79.2	1326	80.0	1340	80.9	1352	81.7	46
47	1030	60.9	1124	66.4	1171	69.2	1225	72.4	1259	74.4	1286	76.0	1309	77.4	1327	78.4	1343	79.4	1358	80.3	1373	81.1	1385	81.9	47
48	1058	61.2	1153	66.7	1201	69.5	1255	72.6	1291	74.7	1317	76.2	1340	77.6	1359	78.6	1375	79.6	1391	80.5	1405	81.3	1417	82.0	48
49	1086	61.6	1183	67.1	1231	69.8	1286	72.9	1322	74.9	1349	76.5	1372	77.8	1390	78.8	1407	79.7	1423	80.7	1438	81.5	1450	82.2	49
50	1115	61.9	1212	67.3	1261	70.1	1317	73.2	1353	75.2	1381	76.7	1403	77.9	1422	79.0	1439	80.0	1455	80.8	1470	81.7	1482	82.3	50

Appendix A. (Continued)

Hundred Call Seconds and Percent Use at Various Service Levels for Group Sizes of 51 to 100

The table number indicates the number of calls per 1000 encountering all equipment in the group busy

Trunks	Table 1		Table 5		Table 10		Table 20		Table 30		Table 40		Table 50		Table 60		Table 70		Table 80		Table 90		Table 100		Trunks
	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	CCS	% Usage	
51	1143	62.3	1241	67.6	1291	70.3	1348	73.4	1384	75.4	1412	76.9	1435	78.2	1454	79.2	1471	80.0	1488	81.1	1503	81.9	1515	82.5	51
52	1171	62.6	1271	67.9	1322	70.6	1374	73.6	1416	75.6	1444	77.1	1467	78.4	1486	79.4	1503	80.3	1520	81.2	1535	82.0	1548	82.7	52
53	1200	62.9	1301	68.2	1352	70.9	1410	73.9	1447	75.8	1475	77.3	1499	78.6	1518	79.6	1536	80.5	1553	81.4	1568	82.2	1581	82.9	53
54	1228	63.2	1330	68.4	1382	71.1	1441	74.1	1478	76.0	1507	77.5	1531	78.8	1551	79.8	1568	80.7	1585	81.5	1600	82.3	1614	83.0	54
55	1256	63.4	1360	68.7	1412	71.3	1472	74.3	1509	76.2	1539	77.7	1563	78.9	1583	79.9	1601	80.9	1618	81.7	1633	82.5	1646	83.1	55
56	1285	63.8	1390	68.9	1443	71.6	1503	74.6	1541	76.4	1571	77.9	1595	79.1	1615	80.1	1633	81.1	1650	81.8	1666	82.6	1679	83.3	56
57	1313	64.0	1419	69.2	1473	71.8	1534	74.8	1572	76.6	1602	78.1	1627	79.3	1647	80.3	1666	81.2	1683	82.0	1698	82.8	1712	83.4	57
58	1342	64.3	1449	69.4	1504	72.0	1565	74.9	1604	76.8	1634	78.3	1659	79.4	1680	80.5	1698	81.4	1715	82.1	1731	82.9	1745	83.6	58
59	1371	64.6	1479	69.6	1534	72.2	1596	75.1	1635	77.0	1666	78.4	1691	79.6	1712	80.6	1731	81.5	1748	82.3	1764	83.1	1778	83.7	59
60	1400	64.8	1509	69.9	1565	72.4	1627	75.3	1667	77.2	1698	78.6	1723	79.8	1744	80.8	1763	81.7	1780	82.4	1797	83.2	1811	83.8	60
61	1428	65.0	1538	70.1	1595	72.6	1659	75.5	1698	77.3	1730	78.8	1755	79.9	1777	80.9	1796	81.8	1813	82.6	1830	83.3	1844	84.0	61
62	1457	65.3	1570	70.3	1626	72.9	1690	75.7	1730	77.5	1762	78.9	1787	80.1	1809	81.1	1828	81.9	1845	82.7	1863	83.5	1877	84.1	62
63	1486	65.5	1599	70.5	1657	73.1	1722	75.9	1762	77.7	1794	79.1	1819	80.2	1842	81.2	1861	82.1	1878	82.8	1896	83.6	1910	84.2	63
64	1516	65.8	1630	70.7	1687	73.2	1752	76.1	1794	77.9	1826	79.3	1851	80.3	1874	81.3	1894	82.2	1911	82.9	1929	83.7	1943	84.3	64
65	1544	66.0	1660	70.9	1718	73.4	1784	76.3	1825	78.0	1858	79.4	1834	80.5	1907	81.5	1926	82.3	1944	83.1	1962	83.9	1976	84.4	65
66	1574	66.2	1690	71.1	1749	73.6	1816	76.4	1857	78.2	1890	79.6	1916	80.6	1939	81.6	1959	82.5	1977	83.2	1995	84.0	2009	84.6	66
67	1603	66.4	1721	71.3	1780	73.8	1847	76.6	1889	78.3	1922	79.7	1948	80.8	1972	81.8	1992	82.6	2010	83.3	2028	84.1	2042	84.7	67
68	1632	66.7	1751	71.5	1811	74.0	1878	76.7	1921	78.5	1955	79.9	1981	80.9	2004	81.9	2024	82.8	2043	83.4	2061	84.2	2076	84.8	68
69	1661	66.9	1781	71.7	1842	74.2	1910	76.9	1953	78.6	1987	80.0	2013	81.0	2037	82.0	2057	82.9	2076	83.6	2094	84.3	2109	84.9	69
70	1691	67.1	1812	71.9	1873	74.3	1941	77.0	1985	78.8	2019	80.1	2046	81.2	2069	82.1	2090	83.0	2109	83.7	2127	84.4	2142	85.0	70
71	1720	67.3	1842	72.1	1904	74.5	1973	77.2	2017	78.9	2051	80.3	2078	81.3	2102	82.2	2123	83.1	2142	83.8	2160	84.5	2175	85.1	71
72	1750	67.5	1873	72.3	1935	74.7	2004	77.3	2048	79.0	2084	80.4	2111	81.4	2134	82.3	2156	83.2	2175	83.9	2193	84.6	2209	85.2	72
73	1779	67.7	1903	72.4	1966	74.8	2036	77.5	2080	79.1	2116	80.5	2143	81.6	2167	82.4	2189	83.3	2208	84.0	2227	84.7	2242	85.3	73
74	1809	67.9	1934	72.6	1997	75.0	2067	77.6	2112	79.3	2148	80.6	2176	81.7	2200	82.6	2222	83.4	2241	84.1	2360	84.8	2276	85.4	74
75	1838	68.1	1965	72.8	2028	75.1	2099	77.8	2145	79.4	2181	80.8	2208	81.8	2233	82.7	2255	83.5	2275	84.2	2293	84.9	2309	85.5	75
76	1868	68.3	1995	72.9	2059	75.3	2130	77.9	2176	79.5	2213	80.9	2242	81.9	2265	82.8	2288	83.6	2308	84.3	2327	85.0	2342	85.6	76
77	1898	68.5	2026	73.1	2091	75.4	2162	78.0	2209	79.7	2245	81.0	2274	82.0	2298	82.9	2321	83.7	2341	84.4	2360	85.1	2376	85.7	77
78	1927	68.6	2057	73.3	2122	75.6	2194	78.1	2241	79.8	2278	81.1	2306	82.1	2331	83.0	2354	83.8	2374	84.5	2393	85.2	2410	85.8	78
79	1957	68.8	2088	73.4	2153	75.7	2226	78.3	2273	79.9	2310	81.2	2339	82.3	2364	83.1	2387	83.9	2408	84.6	2427	85.3	2443	85.9	79
80	1986	69.0	2118	73.5	2184	75.8	2258	78.4	2305	80.0	2343	81.3	2372	82.4	2397	83.2	2420	84.0	2441	84.7	2460	85.4	2477	86.0	80
81	2016	69.1	2149	73.7	2215	76.6	2290	78.5	2337	80.1	2375	81.4	2405	82.5	2430	83.3	2453	81.1	2474	84.8	2493	85.5	2510	86.1	81
82	2046	69.3	2180	73.9	2247	76.1	2322	78.7	2370	80.3	2408	81.6	2437	82.6	2463	83.4	2486	84.2	1507	84.9	2527	85.6	2543	86.2	82
83	2076	69.5	2211	74.0	2278	76.3	2354	78.8	2402	80.4	2440	81.7	2470	82.7	2496	83.5	2519	84.3	2541	85.0	2560	85.7	2577	86.3	83
84	2105	69.6	2242	74.1	2310	76.4	2386	78.9	2435	80.5	2473	81.8	2503	82.8	2529	83.6	2552	84.4	2574	85.1	2593	85.7	2610	86.3	84
85	2136	69.8	2273	74.3	2341	76.5	2418	79.0	2467	80.6	2506	81.9	2536	82.9	2562	83.7	2585	84.5	2607	85.2	2627	85.8	2644	86.4	85
86	2166	70.0	2304	74.4	2373	76.6	2450	79.1	2499	80.7	2538	82.0	2569	83.0	2595	83.8	2618	84.6	2640	85.3	2660	85.9	2678	86.5	86
87	2196	70.1	2335	74.6	2404	76.8	2482	79.3	2532	80.8	2571	82.1	2601	83.1	2628	83.9	2652	84.7	2674	85.4	2694	86.0	2711	86.6	87
88	2226	70.3	2366	74.7	2436	76.9	2514	79.4	2564	80.9	2604	82.2	2634	83.2	2661	84.0	2685	84.8	2707	85.5	2727	86.0	2745	86.6	88
89	2256	70.4	2397	74.8	2467	77.0	2546	79.5	2596	81.0	2636	82.3	2667	83.3	2694	84.1	2718	84.8	2740	85.5	2761	86.1	2778	86.7	89
90	2286	70.6	2428	74.9	2499	77.1	2578	79.6	2629	81.1	2669	82.4	2700	83.3	2727	84.2	2751	84.9	2773	85.6	2794	86.2	2812	86.8	90
91	2317	70.7	2459	75.1	2530	77.2	2611	79.7	2661	81.2	2702	82.5	2733	83.4	2760	84.3	2734	85.0	2807	85.7	2828	86.3	2846	86.9	91
92	2346	70.8	2490	75.2	2562	77.4	2643	79.8	2694	81.3	2735	82.6	2766	83.5	2793	84.3	2817	85.1	2840	85.8	2861	86.3	2880	86.9	92
93	2377	71.0	2521	75.3	2594	77.5	2674	79.9	2726	81.4	2767	82.6	2798	83.6	2826	84.4	2851	85.2	2873	85.8	2895	86.4	2913	87.0	93
94	2407	71.1	2553	75.4	2625	77.6	2706	80.0	2759	81.5	2800	82.7	2831	83.7	2859	84.5	2884	85.2	2907	85.9	2928	86.5	2947	87.1	94
95	2437	71.3	2584	75.6	2657	77.7	2739	80.1	2791	81.6	2833	82.8	2864	83.8	2892	84.6	2917	85.3	2940	86.0	2962	86.6	2981	87.2	95
96	2468	71.4	2615	75.7	2689	77.8	2771	80.2	2824	81.7	2865	82.9	2897	83.8	2925	84.6	2950	85.4	2973	86.0	2995	86.6	3014	87.2	96
97	2498	71.5	2646	75.8	2721	77.9	2803	80.3	2857	81.8	2898	83.0	2930	83.9	2958	84.7	2984	85.4	3007	86.1	3029	86.7	3048	87.3	97
98	2528	71.7	2678	75.9	2752	78.0	2836	80.4	2889	81.9	2931	83.1	2963	84.0	2991	84.8	3017	85.5	3040	86.2	3062	86.8	3082	87.4	98
99	2559	71.8	2709	76.0	2784	78.1	2868	80.5	2921	82.0	2964	83.2	2996	84.1	3024	84.9	3050	85.6	3073	86.2	3096	86.9	3116	87.5	99
100	2589	71.9	2740	76.1	2816	78.2	2900	80.6	2954	82.1	2996	83.2	3029	84.1	3057	84.9	3083	85.7	3107	86.3	3129	86.9	3149	87.5	100

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Multi-tenant Services

This report will help you to:

- Benefit from emerging multi-tenant services.
- Follow regulatory and economic issues that have led to the development of multi-tenant services.
- Understand and apply multi-tenant service capabilities.

Telecommunications has long been a mysterious process known only to telephone company management. Since the divestiture of AT&T, and largely because of the brilliant advances in technology, it has become possible for entrepreneurs to sell telephone connection equipment and to resell long-distance service at a discount.

In the short time which has elapsed since divestiture, new start-up companies are exploiting opportunities that have appeared in this climate of competitive telecom sales. The most prevalent group is the recent coventuring businesses involving building developers and new telecommunications companies. They are called "multi-tenant service vendors" and provide attractive and cost-effective telephone services with exciting amenities, as a service of the building, which increase the value to tenants of locating in the building. This report summarizes the history and development of the multi-tenant service industry and informs readers about the technologies offered by multi-tenant services: the advantages, the difficulties, the most likely directions of technological growth, and the most important participants.

MULTI-TENANT SERVICES EXPLAINED

Multi-tenant or shared-tenant telecommunications are telephone services for building or office park tenants provided from a facility within the same building or complex. Multi-tenant service is essentially an in-house telephone company (or service company) for office buildings, industrial complexes, and shopping malls, and can offer a complete range of telecom services with networking capabilities.

The multi-tenant facility consists of a PBX switching system operating as a miniature telephone company (see photo). On one side of the switch are trunks that carry traffic to and from the building. On the other side of the switch, lines lead to the telephone extensions of individual tenants. The PBX automatically connects lines to outgoing trunks, and it connects incoming calls to the appropriate line extensions. Multi-tenant service is a valuable facility, allowing several tenants in the same locale to share the cost of equipment and telephone trunks. It is the job of the multi-tenant service operator to manage call switching so that less expensive trunk volumes can be shared.

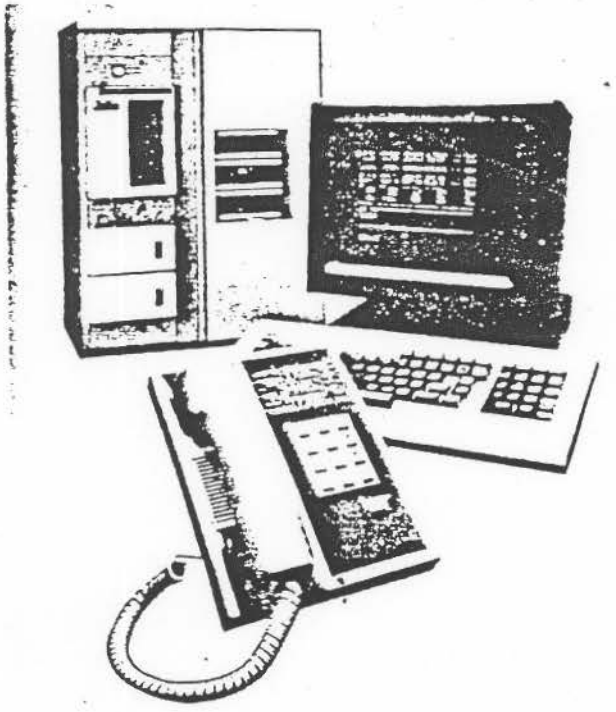
Benefits

Volume discounts are available to telephone users of large blocks of trunk time. In a multi-tenant telephone system such discounts can be shared by the users and by the multi-tenant service operator. Furthermore, economies of scale are also involved in the sharing of local trunks, which bear fixed monthly costs.

In addition to these cost savings, multi-tenant services can provide state-of-the-art telephone equipment, features, and services that are unavailable from typical telephone utilities (telcos).

Developed exclusively for Datapro by Michael Winn, a telecommunications/office automation consultant. Mr. Winn perfected one of the first, most successful multi-tenant services during 1984, at Olympic Plaza in Los Angeles.

Multi-tenant Services



A Modern PBX, the Inteccom IBX

For example, the multi-tenant operator can provide tenants with a broader range of telephone terminals, and other station equipment. Although using a specific make of PBX by the operator does limit choices, PBX product lines generally include a more advanced selection of telephone terminals and features than those sold and supported by telcos.

Installation and customer service are typically immediate in a multi-tenant environment. Given the limited market of multi-tenant businesses, operators can not afford dissatisfied clients and must strive to keep them from migrating to telco service. Operators have the opportunity to carefully select a staff of on-premises personnel, as well as state-of-the-art equipment engineered to provide almost failsafe features.

Multi-tenant service features

Multi-tenant service features will vary. The business is influenced easily by customer demand, however, and the complete range of modern PBX features are available to individual users, just as if they were Fortune 1000 executives with large budgets to spend on convenience items. But most of the services offered by a good PBX system are both cost saving *and* productivity enhancing. They are tools that improve good business communications, resulting in more closed sales, faster delivered product, and better professional relationships. In addition to typical PBX features such as call waiting, call forwarding, automatic dialing, conference calling, call screening, etc., these services can also include:

- Message Centers—provide professional telephone answering services. Such message centers equip telephone operators with video screens: when a tenant's number is called, the screen displays details about the tenant's whereabouts and call handling preferences.

- Voice Messaging—gives callers an alternative to leaving written messages. State-of-the-art voice messaging machines can be programmed to call the recipient with the stored messages periodically until the message is delivered.

- Least Cost Routing—automatically selects the least expensive route for outbound calls. The multi-tenant operator has the responsibility to keep track of carrier rate fluctuations.

- Call Detail Recording—provides the tenant with telephone records which can include a coded report for individual client billing systems.

- Facilities for data communications that can network together data terminals within each tenant's own offices also provide the right configuration of technolgoy for communicating off-premises.

- Intelligent building facilities—including building environmental control, security, and alarm systems.

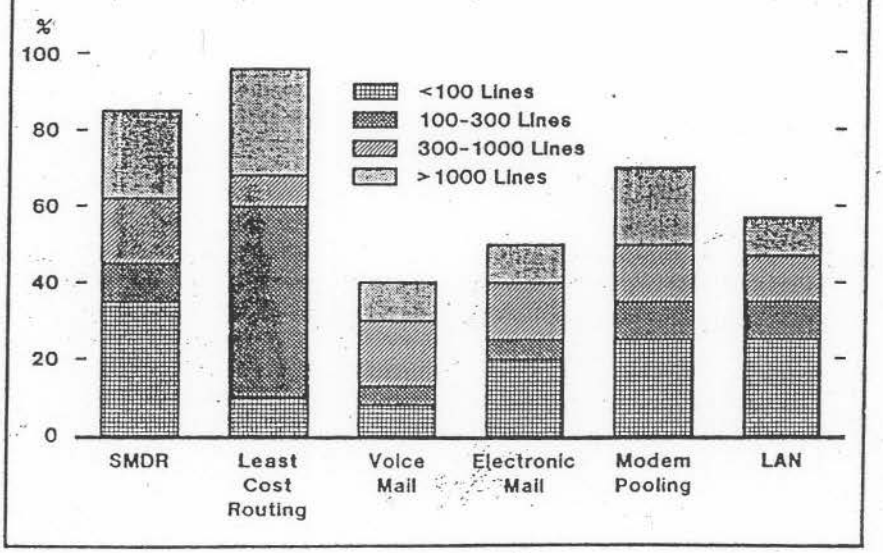
Some of these features are explained in greater detail further on in this report. Of greatest potential value to multi-tenant subscribers, however, is a dedicated support staff available to help manage telephone and data communications needs, an intangible asset which does not lend itself to neat definitions or generalizations.

HISTORY

Bell Canada is reputed to have initiated the present approach to shared tenant telecommunications services. Bell Canada's intent was to provide telephone services through telephone switching gear located in a few larger buildings in Toronto and Montreal. Existing switching equipment was impractical, however, because different groups of users wanted different groups of telephone features. At that time, telephone switch gear was mechanical, not intelligently driven by digital computer devices. Such mechanical devices can not distinguish and assign attributes to incoming or outgoing calls. In 1976, the Canadian Bell Company requested a proposal from Nothern Telecom, a digital PBX manufacturer, to develop software for a PBX switch

The economics of STS

Figure 1 User interest in multitenant features



SID HOOSEIN

MOST STUDIES on shared tenant services (STS) are from the perspective of an owner/developer and a STS provider. These studies include business cases, profitability analyses, market sizing and segmentation studies. However, not much has been said about the economic value of this service to end users in the business community.

Assessing STS' economic value is of interest not only to end users, but also to real estate developers, equipment manufacturers, network providers, regulators and STS providers. This is because the future of the service hinges upon the value it brings to the ultimate customer.

Analysis of the economic value becomes complex if all the costs incurred in owning and operating a telecommunications system are considered. Costs include the tangible costs of equipment, and also the intangible costs of risks involved and factors such as responsiveness, flexibility and reliability of service. Studies conducted by The Eastern Management Group, Parsippany, N.J., have shown that, based on the current service charges, STS can be an attractive proposition.

The market for STS is largely untapped and highly fragmented. Service providers include a large number of single building owner-operators and a few large multibuilding operators such as ShareTech and RealCom. (ShareTech is a joint venture between AT&T Information Systems and United Technologies, while RealCom is a subsidiary of Satellite Business Systems.)

STS includes basic and enhanced services. Basic services consist of tele-

Continued on page 68

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Table 1 Shared tenant service offering (755 stations)

Expense statement	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Equipment & service rate	0	(300,480)	(302,926)	(305,519)	(308,268)	(311,181)
Local service rate	0	(46,200)	(48,972)	(51,910)	(55,025)	(58,326)
Long distance rate	0	(254,575)	(269,850)	(266,041)	(303,203)	(321,395)
Long distance misuse savings	0	0	0	0	0	0
Moves & changes charge	0	(4,725)	(5,009)	(5,309)	(5,628)	(5,965)
Total costs before tax	0	(605,980)	(626,756)	(648,779)	(672,123)	(696,868)
Tax Savings	0	302,990	313,378	324,390	336,062	348,434
Total costs after tax	0	(302,990)	(313,378)	(324,390)	(336,062)	(348,434)

Discount rate	A.T. NPV 5 years
5.0%	(1,402,511)
7.5%	(1,308,496)
10.0%	(1,224,039)

phone equipment, local telephone service, long distance telephone service and maintenance and administration. Enhanced services include message center, voice mail, electronic mail, word processing, data processing including high speed data transmission, database services and local area networks (LANs). As the industry grows, many new services such as video teleconferencing also will be available.

To study the economic value provided by STS, determine the costs incurred in owning or leasing a standalone PBX and compare it with the shared services costs.

With STS, the basic costs involved are an equipment and service rate, local telephone service rate, long distance telephone service rate, and moves and changes. The equipment and service rate is quoted as the rate per station per month. This varies depending on the type of instrument and features.

This service rate includes station equipment, use of common equipment and software, installation, maintenance, electricity, system management, training and usually a direct inward dialing (DID) number per extension. A service agreement may be available to cap the rates for 3 to 10 years depending on the type of agreement. Table 1 shows the costs involved for 755 stations. Similar studies can be done for smaller configurations. Other cases examined were with 26 and 302 stations.

Computing the costs involved in an STS is relatively simple. Costs are usually specified in a service agreement. The chance of being hit with hidden charges is minimal. Since providers are anxious to develop this new business, it is possible to negotiate a favorable agreement especially if the tenant is an anchor tenant, occupying a large portion of a building.

A tenant can remove many risks associated with unplanned telecommunications expenditures through negotiation.

PBX vendors never clearly specify the costs of owning and operating a telecommunications system. Moreover, the PBX vendor is not responsible for the entire telecommunications system. Hence, it is unrealistic to expect a vendor to analyze the telecom requirements and make accurate cost estimates.

A good telecommunications staff must control costs. Divestiture has increased the responsibilities of a telecommunications staff and also the salary levels. One survey has indicated that more than 50% of the telecom managers earn above $40,000. Even with a competent staff, all the risks involved in owning and operating a telecommunications system cannot be removed.

The life cycle cost of owning a system should be considered against the cost of STS. The length of the life cycle is dependent on factors such as line size, nature of the business and technology. A 5- to 7-year horizon is usually appropriate. The measure commonly used is the net present value of the estimated cash outflows.

The net present value considers the time value of money. It can be regarded as the cash that has to be invested today at the prevailing interest rate to meet the future cash outflows for a project. Thus, to compare two projects requiring two different streams of cash outflows, the project with the lower net present value is preferable. Table 2 shows the estimated expenditures for owning a PBX with 755 stations. If a discount rate of 7.5% is used, the net present value of cash expenditures is 13% higher.

This analysis does not take into account the economic value of benefits from using shared services. Benefits such as responsiveness, flexibility and reliability that cannot be easily quantified further strengthen the case for STS.

Similar results were obtained for cases with 26 and 302 stations. Thus it can be shown that the savings accrue regardless of the size of the system. For smaller systems, one benefit that is not easily quantified is the availability of features that cannot be justified in a tenant's private telecommunications system.

Favorable costs for STS are derived from economies of scale in the major cost components. These components include local and long distance telco rates; common equipment cost; maintenance, installation and administration expenses; and miscellaneous costs including rent for PBX space, electricity and installation.

The current regulatory environment does not allow end users to derive maximum benefits from economies of scale from local telephone service. Some Bell regional holding companies are aggressively lobbying against STS and, as a result, service providers are keeping a low profile on savings from this cost component.

Savings can come from sources such as trunk sharing, special access lines to route long distance calls, and local loop bypass.

The prospects for savings from local

Continued on page 70

Table 2 Leased PBX operated by tenant (755 stations)

Expense statement	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Equipment, install, fitup-						
Amort. of leasehold improv.*	0	0	0	0	0	0
Amort. of PBX room fitup*	0	0	0	0	0	0
Lease of equipment (1)	0	(270,900)	(270,900)	(270,900)	(270,900)	(270,900)
Staffing-						
Administration	0	(35,000)	(37,100)	(39,325)	(41,686)	(44,187)
Receptionist	0	0	0	0	0	0
Other operating expenses-						
Maintenance	0	0	(36,240)	(38,414)	(40,719)	(43,162)
Rent for PBX space	0	(3,750)	(3,975)	(4,214)	(4,466)	(4,734)
Insurance	0	(5,375)	(5,698)	(6,039)	(6,402)	(6,786)
Electricity	0	(4,530)	(4,802)	(5,090)	(5,395)	(5,719)
Moves and changes charge	0	(6,615)	(7,012)	(7,433)	(7,879)	(8,351)
Local service-(COs, DIDs, # Grps, etc. . .)						
Trunk installation	(11,896)	0	0	0	0	0
Service charges	0	(48,672)	(51,592)	(54,688)	(57,969)	(61,447)
Long distance costs-						
Installation	0	0	0	0	0	0
Service and usage charges	0	(275,469)	(291,997)	(309,517)	(328,088)	(347,773)
Network optimization	0	(5,000)	(5,300)	(5,618)	(5,955)	(6,312)
Call detail record costs-						
Installation	0	0	0	0	0	0
Internal support	0	(5,000)	(5,300)	(5,618)	(5,955)	(6,312)
Long distance misuse savings	0	0	0	0	0	0
Total costs before tax	**(11,896)**	**(660,311)**	**(719,916)**	**(746,857)**	**(775,414)**	**(805,685)**
Tax savings	5,948	330,156	359,958	373,428	387,707	402,842
Plus ITC benefit	0	0	0	0	0	0
Total costs after tax	**(5,948)**	**(324,207)**	**(359,958)**	**(373,428)**	**(387,707)**	**(402,842)**

	Discount rate	A.T. NPV 5 Years
	5.0%	(1,604,344)
	7.5%	(1,496,481)
	10.0%	(1,399,621)

* Tenant chose to include these items in the equipment lease

** Does not include consultant fees for analysis of needs and equipment selection

telephone service are bright. The most recent regulatory developments in Illinois Bell territories indicate that intra-LATA (local access and transport area) competition is inevitable. When this happens, STS users will benefit first from the economies that can be derived. This is because of the aggregation of demand for this service in a building.

Long distance telephone service is a source for savings, especially for the small- and medium-sized firms. Long distance use is monitored closely by STS providers. Station message detail recording (SMDR) is a standard feature with shared services. Routine network optimization studies also are used to ensure that the type of long distance service selected is optimal in terms of the vendor and the type of lines, such as WATS and FX lines. This service is transparent to the STS customer as he shares a large virtual trunking network.

To illustrate the economies involved, consider a 3-minute call from Washington to New York. A direct distance dialing (DDD) call costs $1.28. A call on a WATS line (Band 2) costs 72¢, a 43% savings. On an FX line, the same call costs only 36¢, a savings of 71%. Small- and medium-sized firms cannot take maximum advantage of these savings because they are unequipped to conduct traffic engineering studies and optimize the service type. Moreover, the volume of traffic on an individual basis does not justify such studies or the installation of SMDR to track long distance calls. As a result, even if they have WATS and FX lines, there usually is an overflow on DDD lines.

The economies of scale derived from common equipment and software enable the availability of advanced PBX features to all users. Figure 1 shows user interest by line size for commonly available features such as SMDR, least cost routing, voice mail, electronic mail, modem pooling and LANs. STS provides these users with many enhanced services in a cost effective manner.

The message center is an enhanced service that becomes cost-effective for tenants subscribing to STS. The message center eliminates the need for a secretary to answer the telephone and frees the secretarial staff for more productive administrative work.

Secretarial cost per call is estimated at $1.09. This includes salary, equipment, furniture and rent for the desk space. By using a message center, this cost can be brought down to 18¢ per call. Using a message center also could eliminate the need for multibutton sets

Continued on page 72

and thus reduce equipment costs.

Another economic value derived from using common equipment is the flexibility that it provides to the tenants. By using STS, a small high growth company can invest its capital in the business rather than in the telecommunications equipment. As the company grows it can add more stations rather than upgrade the PBX.

Perhaps the most economic value derived from STS is the service aspect. The lost business from an unanswered client or customer phone call cannot be easily measured. Most service providers have on-site personnel for maintenance, installation and administration. The responsiveness and reliability of service is usually very good. The incentive for providing this type of service is often built into the agreement as imposition of penalties for downtime.

Another aspect of the service is the single vendor concept. STS eliminates the need to deal with multiple vendors. In the post-divestiture environment, the telecommunications network has become extremely complex. If a problem occurs, it is difficult to determine whether it is with the premise equipment or with the transmission facilities. This leads to expensive and unnecessary service calls from the wrong vendors. The end user has no control. While the different vendors resolve where the problem is and this takes time, he is completely out-of-service. STS eliminate such problems, saving time and money.

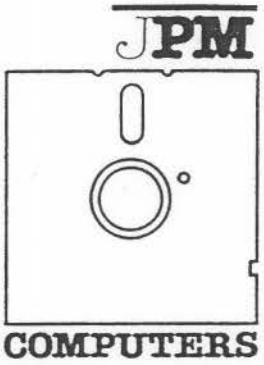
Finally, cost savings accrue as a result of economies of scale derived from miscellaneous costs such as rent for the PBX room, spares, electricity and installation.

The future of STS is promising. As providers capture the business in more buildings in large metropolitan areas, networking capabilities will create large private networks providing many enhanced services such as video teleconferencing and software defined networks. Both large users and the smaller tenants, who could not otherwise justify the cost of its use, will benefit from these services.

The deployment of new technologies will enable providers to deliver enhanced services to all users. The economies derived from local and long distance telephone services, common equipment and software, on-site maintenance staff and other factors make shared services a viable and cost effective alternative to owning and operating a telecommunications system. □

Evaluating the Joint Venture in Shared Tenant Services

by James Sinopoli and Amy Kays-Teran



Increasingly, developers, property owners, and property managers are exploring the option of providing shared tenant services (STS) to their tenants.

STS projects typically offer a menu of services that may include discounted long distance service, equipment rental, on-site administration and maintenance of telephone and computer equipment, and access to advanced telephone and data features.

STS has evolved as a tenant amenity with the potential to positively affect project lease-up by offering tenants "one-stop shopping" for most communication services and many office automation needs. Especially for small- to medium-size users, STS may provide a cost-competitive solution to telephone applications. For the owner, bringing high-tech services into a property may increase profits through improved tenant satisfaction and lower turnover.

Because it is in its infancy, STS participants have developed several arrangements to define the relationship between provider and developer. Two of the more common arrangements are the concession fee basis and the joint venture.

In a concession fee arrangement, the STS provider handles all financial, managerial, and operational aspects of the business. The property owner may invest in building cabling, abate provider's rent, or pay for the finish-out of the equipment room, but essentially all costs for equipment or installation are borne by the provider.

In return for granting exclusive rights to provide STS for the building, the owner is paid a percentage of revenues. In most cases, the owner would be paid based on penetration or gross revenues. The major disadvantage of this arrangement, from the owner's point of view, is the difficulty in defining a project payment plan that is acceptable to both parties.

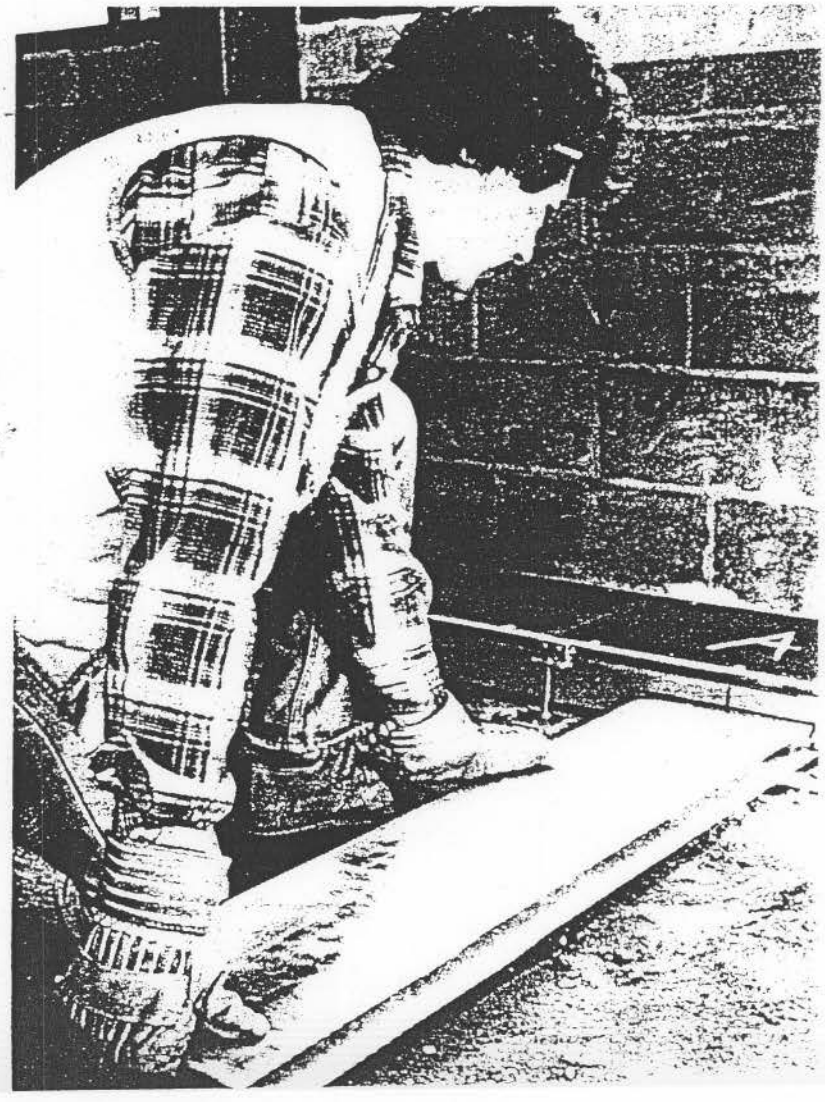
In a joint venture, the investment is shared equally, and the owner actively participates in the shared tenant components. Unlike a fee arrangement, however, a joint venture project has a plethora of issues that must be negotiated.

The remainder of this article will discuss some of the issues affecting an owner's choice for a joint venture partner. Without careful analysis of the joint venture agreement and business pro forma, joint venture agreements may turn out to be a very one-sided proposition, heavily favoring the STS provider. In too many cases, the owner's involvement has been limited to a review of a contract drawing and

Cost of equipment

Owners typically do not have the telecommunications expertise to evaluate project needs and make an equipment choice. For this reason, equipment vendors may choose to contract directly with a service provider.

In the joint venture situation, it is important for the owner to know the relationship between a potential STS partner and any equipment manufacturers. It is not uncommon for the provider to take advantage of volume contracts with the manufacturers and purchase equipment at deeply discounted prices. It would be advisable for the manager to inquire about this and make any investment based on these discounts.



An electrician installs a branch raceway duct, which will house the wires needed to link tenants with the central computer/PBX equipment.

Sample Price List for Shared Tenant Services

Dial tone—Local service is provided at cost to tenants; revised and prorated as necessary.

Dedicated (data) service—Installation and equipment are provided at cost to tenants. Monthly recurring charges are:

Port charge	$20.00
Port maintenance	$4.00/port

Station equipment—Monthly recurring charges are:

Single line station	$17.00
Smartset	$23.00
4-button Dterm	$37.50
16-button Dterm	$40.50

Maintenance of equipment—$3.50 per station per month.

Software feature reprogramming—Moves, adds, changes to prewired locations: $17.50 per request.
Moves and adds to non-prewired locations, deletions to prewired locations: No charge.

Installation/deinstallation—Prewired locations: Installation, no charge; deinstallation, $45.00.
Non-prewired locations: Installation, $125.00; move, $125.00.

Long distance service rates—Rates below include continental United States, Puerto Rico, U.S. Virgin Islands. Calls rounded to the next whole minute.

Mileage	Business day	Evening	Night/ weekend
1– 50	$ .23	$ .13	$ .08
51– 300	.32	.19	.11
301– 450	.35	.21	.12
451– 925	.36	.21	.13
926–1,900	.37	.22	.13
1,901–3,000	.42	.25	.15
3,001–5,500	.45	.27	.16

Definition of long distance time periods—
Business day: 8:00 am–5:59 pm, Mon.–Fri.
Evening: 6:00 pm–10:59 pm, Sun.–Fri.
Night/weekend: 11:00 pm–7:59 am, all days
8:00 am to 10:59 pm, Sat.
All other calls will be billed at AT&T's prevailing rates.

Long distance discount structure—

Up to $500	0
$501–$1,000	10% of amount over $500
$1,001–$5,000	20% of amount over $1,000 plus $75
$5,001–$10,000	25% of amount over $5,000 plus $750
Over $10,000	30% of amount over $10,000 plus $2,000

Directory assistance—Long distance and local directory assistance will be billed at the rates currently in effect from AT&T.

Training—Training in excess of initial training: $20 per hour.

Cabling

In most cases, building cabling for use in providing telephone service to STS subscribers is provided at the building owner's expense. Although cabling is a part of the expense of STS project start-up, it has a life in the building of 20 to 30 years and increases the value of the property.

Management fees

Owners and managers are interested in joint ventures because of the upside potential, but STS operations require large capital investments, have a long lead time before profitability and offer thin profit margins. In addition, joint venture agreements require payment of all operating expenses from joint venture revenues.

In some cases, a monthly management fee is also paid to the provider, usually on a per-active-port basis. This fee is paid before profits are shared and thus creates an arrangement where the owner is more at risk financially than the provider.

Unprofitability

An STS joint venture contract should contain a provision in case of project unprofitability. A provider should acknowledge that this is a possibility and agree to terms both for disbanding the joint venture and for splitting any remaining assets or liabilities.

It is also important to include provisions for assisting tenants who are STS customers in their arrangements for alternative telephone service to avoid interruption of their business operations.

Sale of the building

While many owners plan to turn over a project only a few years after lease-up, most shared tenant services projects take between three and five years to become profitable. For this reason, an STS provider will attempt to sign a five-to-fifteen-year contract with the owner.

Some providers may also be inflexible in their provision for the sale of the building during this time period, requiring the joint venture contract to extend to any new owner. These terms could adversely affect salability, especially if the venture has not reached a point where profits have been achieved.

Assessment of STS providers

Providing communications services to a diverse group of businesses is a complicated task that requires significant commitment to the industry.

The qualified provider will have expertise in voice and data systems, systems installation, network management, marketing, and billing, as well as a knowledge of rapidly changing technologies. It will also employ trained service technicians who will assume full responsibility for maintenance and complaints. In this way, the manager will not be distracted from proper-

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provide assistance to STS users.

The provider chosen should have access to multitude of equipment and service vendors. provider with ties to any one manufacturer cannot objectively select and purchase equipment which truly fits an application.

Annual reports and balance sheets can tell the developer whether a provider will be capable of serving tenants for as long as they may desire service. A provider's financial resources are of the utmost importance in the selection process. An owner does not want tenants to be left without telephone service.

Lastly, the manager should examine a sample menu of prices and services a provider proposes to offer tenants (Figure 1) and determine if they are competitive. The marketability of proposed services will ultimately affect project profitability. Tenants will not subscribe to an in-house, shared service if it is more expensive than service they can get on their own or if it does not offer the features they most want.

Shared paper shredders, video teleconferencing, or elaborate "bells and whistles" on the system are fine, but most businesses are looking for reliable telephone service.

Conclusion

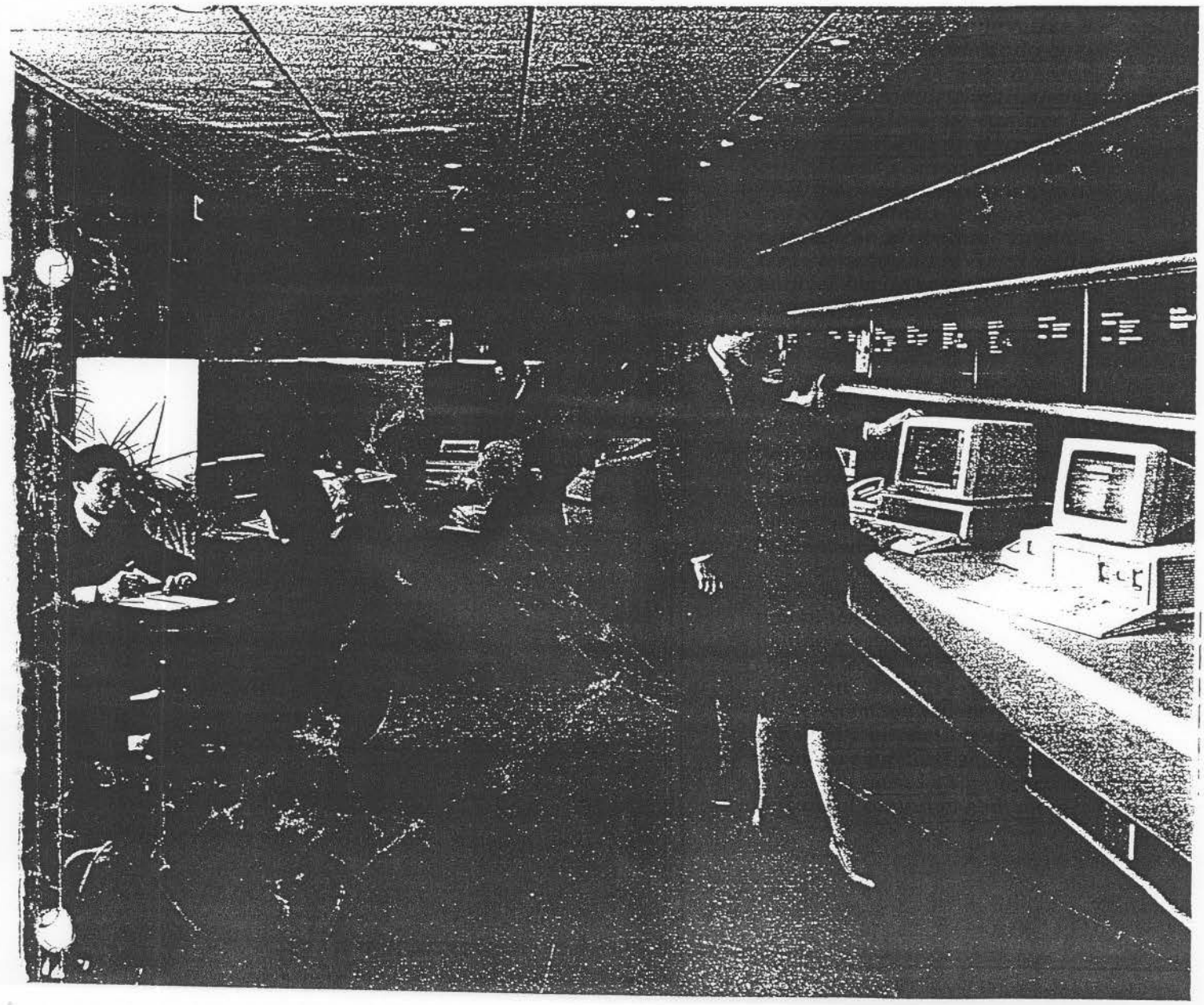
Instituting shared communication services for tenants in new or existing properties is becoming more and more commonplace. As this occurs, buildings not offering high-tech services to tenants may lack the competitive edge increasingly necessary in many of today's soft real estate markets.

Owners who respond to market demands by contracting with an expert professional STS provider, one committed to providing good long-term telephone service, should find favorable tenant reactions and positive project profitability.

JPM

COMPUTERS

Especially during the leasing phase, an on-site business information center, such as this one created by Integrated Business Systems in Atlanta, provides a one-stop center for presentations and purchases of equipment and shared services.



Reduce costs and generate revenue with telecommunications

BY STEPHEN G. WUEST, CPA, AND MELVIN T. GERTZ

Financial managers are constantly faced with the pressures of running a cost efficient organization, and must look for new and innovative ways to reduce costs and generate revenue. Telecommunications can provide the financial manager with opportunities to save money and produce income. Ideas such as disposable or dispensible telephones, call tracking systems, and pay telephones can all become important steps to improving the financial health of an organization.

With never-ending pressures to reduce costs and operate more efficiently, healthcare financial managers should periodically review the organization's existing telecommunications equipment and services. There have been, and will continue to be, rapid changes in technology being marketed by a proliferation of telecommunication vendors touting a vast array of equipment and services.

Admittedly, this explosion in the telecommunications industry is not only responsible for many innovative products and services; it has also caused a significant amount of confusion and uncertainty for many healthcare organizations faced with making telecommunications decisions.

Some of the concepts discussed will provoke new ideas or resurrect old ones that may reduce telecommunication costs, improve service levels, or generate new sources of revenue.

Many healthcare organizations have probably investigated some of the topics discussed here. For a variety of reasons, a decision may have been made that these ventures were not in the best interest of the organization. However, in the past few years, the telecommunications and healthcare industries have changed markedly.

As a result, some of the concepts presented, even though they may have been previously considered and rejected, should once again be evaluated. Competitive pressures in the marketplace, changes in pricing structures, product enhancements, and so on, may now provide sufficient incentive for an organization to implement new telecommunications-related products and services.

COST REDUCTION OPPORTUNITIES

RENTAL VERSUS PURCHASE. For those organizations presently renting equipment under long-term agreements or month-to-month leases, the hospital may be paying much more than necessary for the equipment. Even if the equipment is not state-of-the-art or will be replaced within a few years, a financial analysis may indicate that purchasing the existing equipment is an attractive alternative.

Such a purchase can be aggressively negotiated. Vendors have been known to waive termination charges associated with long-term contracts and significantly reduce the purchase price, rather than risk damaging the relationship and losing the eventual sale of a new system. Because it is a very competitive marketplace, the hospital may have more leverage than realized.

PURCHASE OF SINGLE LINE TELEPHONES. For organizations renting single-line telephones in conjunction with an on-site service, consideration should be given to purchasing these instruments. A financial analysis may indicate a rather short payback period. If the decision is made to purchase another system, these single line instruments typically can be reused.

MOVES, ADDS, AND CHANGES. The quantity of requests for telephone equipment moves, adds, and changes (MACs) are generally much higher in a healthcare environment as compared to other industries. Some hospitals are paying thousands of dollars every year to have their

vendor perform these services. In many instances, significant savings can be realized by transfering all or a portion of this function inhouse. A financial analysis of this alternative should be performed. At a minimum, it should be economically justifiable to require hospital personnel to perform the software changes.

INHOUSE SYSTEM MAINTENANCE. Beyond handling daily requests for MACs, larger organizations may want to consider transfering all telephone maintenance inhouse, thereby relying only on the vendor for special projects for emergency situations. This obviously assumes the organization is willing to accept a major responsibility. However, when compared to vendor maintenance contracts, which can be very expensive insurance policies, assuming the responsibility for inhouse maintenance can often be justified for a variety of reasons, including the financial incentives.

EQUIPMENT PILFERAGE. Some patients, visitors, and employees feel that free telephones are a fringe benefit of staying, visiting, or working at the hospital. Hospitals are continually replacing telephones that have been pilfered from patients' rooms, elevators, hallways, and so on. Over time this pilferage can become an expensive situation. One method that may help to reduce theft is to slightly modify the modular jack on the telephone handset and wall cords so they cannot be so easily removed.

Another innovative approach is the use of disposable or dispensable telephones that are sold to the patients upon being admitted to the hospital. These are low cost instruments that the patients can take home with them. These telephones provide an added advantage of reducing the possibility of spreading disease through telephone handsets.

EQUIPMENT AND SERVICE INVENTORY. A physical inventory of all telephone equipment and services that is reconciled to actual billing invoices can often produce interesting results. It is not uncommon to find that an organization is paying for equipment, and sometimes services, that were disconnected or removed several months or years ago. If this situation does exist, the organization may be entitled to a credit from the vendor.

SERVICE CONTRACTS. If possible, the hospital should try to negotiate long-term maintenance contracts with escalation clauses to minimize increases in maintenance costs. These contracts are generally easier to negotiate if the equipment in place is fairly new. Large increases in maintenance charges are a tactic used by some vendors to force an organization into buying new equipment before it is ready.

CONTRACT REVIEW. If the hospital has purchased telephone equipment or services in the past few years, it may be worthwhile to review the original purchase and maintenance agreements to determine if the terms and conditions are still being satisfied. For example, a vendor may notify all of its customers that an across-the-board increase in maintenance rates of 10 percent will occur. The contract, however, may limit rate increases to 5 percent. If the hospital is not policing its contracts, the higher rate may prevail. This situation happens more frequently now that computerized invoicing systems are used. Contract reviews must be performed to ensure that the organization is reaping the benefits of a well-negotiated agreement.

TELEPHONE ABUSE. Sometimes employees will spend an inordinate amount of time making personal calls or have their employer subsidize their long distance calls. These actions result not only in loss of productivity, but also higher local and long distance calling costs. A number of approaches for minimizing this abuse can be used, beginning with stringent policies prohibiting the use of telephones for personal use.

Other measures, such as assigning restrictive "classes of services" to certain telephones (for example, only local calls permitted) or the installation of call accounting devices can also be pursued. Many such devices are available in the marketplace today that can track outgoing calls from a specific telephone. These devices can record

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the number, length, and cost of the call.

REGULAR TESTING OF FACILITIES. Organizations with on-site systems generally have several incoming and outgoing facilities (in/out trunks, DID trunks, WATS lines, tie lines, and so forth). If possible, these facilities should be tested on a regular basis. It is not uncommon to have problems with these facilities resulting in out-of-service conditions that may go undetected for extended periods of time, while the hospital continues to pay monthly charges for less-than-adequate service.

TRANSMISSION FACILITIES. Investigating alternative transmission facilities may be appropriate for those large, multi-location organizations using several tie lines and data circuits between locations. The use of T-1, fiber optics, or microwave facilities may be economically justifiable and provide additional benefits to the organization (high speed transmission, expansion capacity, video transmission, and so forth.)

COST AVOIDANCE OPPORTUNITIES

Several cost reduction opportunities can also be interpreted as cost avoidance opportunities. Therefore, the topics discussed below primarily address two situations: the major expansion of existing facilities and the purchase of new systems.

UNIFORM CABLING PLAN. Any time telephone cabling is required in a renovated or new facility, a uniform cabling plan should be implemented. A uniform cabling plan consists of the same number of pairs of cable to every telephone station outlet (generally four-pair cable) with 30 to 50 percent spare cable between every intermediate distribution frame (IDF) and the main distribution frame (MDF). The incremental cost per foot of cable for four-pair versus two-pair cable, and spare capacity on the IDF, is nominal when compared to labor and material costs for additional cable after renovation or new construction is complete.

> *"Telephone systems can now be viewed as both a cost and revenue center."*

Although the vendor may say its state-of-the-art telephone instruments require only one pair of cable, it may be advisable to install four pairs. Foresight may prepare the hospital for new technologies to be implemented in the future. A good possibility exists that these technologies may piggyback on the existing telephone cable that is already installed throughout the entire facility.

"WIRED FOR" CAPACITY. When purchasing a new telephone system or upgrading an existing system, plan for a sufficient amount of "wired for" capacity. Wired for capacity provides additional room for growth over what is actually operational at the time of system installation. If the system is not sized properly with adequate growth capacity, the organization may quickly reach the point where adding the next telephone will cost thousands of dollars because an additional cabinet or module is required. Adding system capacity after the system is installed can be 20 to 40 percent more expensive than including it in the initial purchase price.

GUARANTEED UNIT PRICES. Most telephone system vendors have at least two, if not more, types of pricing for their products. The two most common types are pre-cutover and post-cutover pricing. Following the system cutover (the actual day the system goes into operation), pricing of additional equipment components, telephone sets, and so on, could be 20 percent greater than it was prior to cutover. This practice is common in the industry.

The best way to protect the organization is to negotiate guaranteed unit prices in the purchase agreement for a certain period of time. These guaranteed prices are especially important if any major modernization or construction projects are planned for the near future. At a minimum, future discounts off the then-current list prices for additional equipment, components, and so forth should be negotiated. Once the telephone system is installed, the hospital is then a captive audience.

PURCHASE AND SERVICE AGREEMENTS. Never sign the first purchase-of-service agreement the vendor submits. Try to negotiate first. Few vendor-prepared contracts provide equal protection for both the seller and the customer; most have a tendency to be

somewhat one-sided in favor of the vendor.

Reputable vendors should have no problem with negotiating a fair and equitable agreement. Large telephone systems will cost several hundred thousand dollars and therefore provide the hospital with a remarkable amount of leverage in obtaining guarantees or concessions from the vendor.

REVENUE GENERATION OPPORTUNITIES

The costs associated with providing telephone service have traditionally been viewed as an operating expense. Divestiture and rapid advances in technology have provided many organizations with the opportunity to operate the telecommunications department as a profit center or, at a minimum, generate revenues to help offset what is generally a significant operating expense. As part of the investigation into the ideas presented below, a review of local, state, and possibly Federal regulations should be included. These regulations may affect how these services are provided.

PHYSICIAN ANSWERING SERVICE. Almost all physicians use an answering service. Recognizing that systems are required to provide this service, hospitals should be in a position to offer a high quality, reasonably priced service, tailored to physicians' needs. In addition to generating a profit, this service has another advantage: it provides one more tie between the hospital and the physician.

RESALE OF LONG DISTANCE SERVICES. In general, as the volume of long distance calling traffic increases, the average cost per minute for calls decreases, assuming the calling facilities are properly configured. For those organizations with on-site telephone systems, the resale of long distance calling services to patients, doctors, students, or other tenants of their facilities presents another opportunity for generating revenues.

An administrative burden is associated with selling these services (for example, billing and collections). However, this effort can be significantly reduced with the implementation of appropriate support systems.

SHARED TENANT SERVICES. Beyond the resale of long distance services, the hospital may want to consider becoming a full service telephone vendor, providing local calling service and telephone equipment. This strategy obviously assumes resources are available and committed to support this activity. Physician office buildings, student dormitories, retirement communities, clinics, and so on, are many times on the hospital campus or in the immediate vicinity. Providing a full spectrum of telephone services to these facilities presents an excellent opportunity to operate the telecommunications department as a profit center.

PAY TELEPHONES. Strategically placed pay telephones can generate a significant amount of revenue for the organization. However, purchasing and maintaining pay telephones can be very expensive. Generally, several low traffic (low profit) areas exist where these telephones should be installed as well. Before taking on this responsibility, the hospital should attempt to negotiate receipt of a larger percentage of the revenues from the local telephone company.

CONCLUSION

A variety of ideas have been presented. However, the extent an organization can benefit from implementing any of these ideas is greatly dependent upon the hospital's unique situation. As these ideas are evaluated in more depth, additional considerations must be addressed before a final decision can be made.

For many years, telephone systems and service have been taken for granted. In the new environment in which hospitals operate, the telecommunications function must now be viewed as both a cost and revenue center, fully deserving of managerial attention. □

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